number 6

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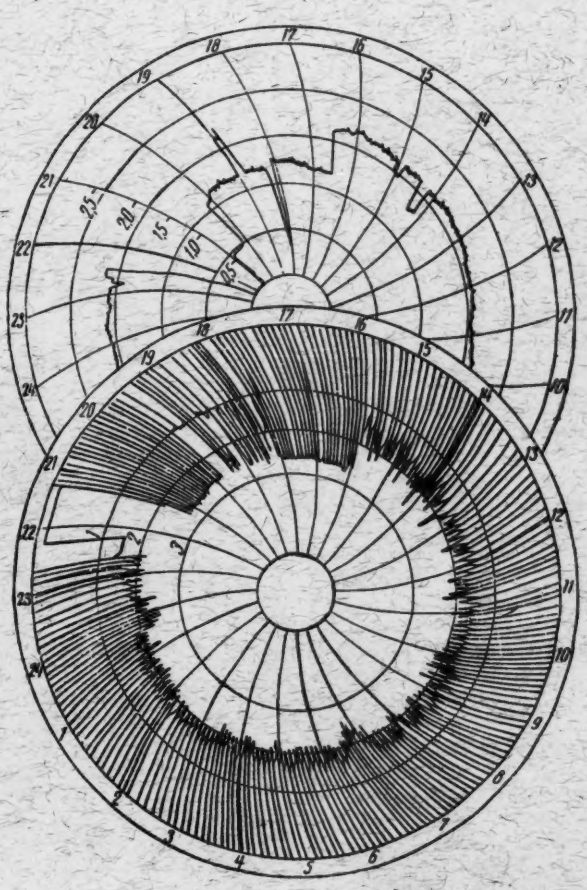
METALLURGIST

translated from Russian



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ON THE ROAD OF TECHNICAL PROGRESS

P. G. Glazkov

Chief Engineer of the Stalino Metallurgical Works

In response to the resolutions of the 20th Congress of the KPSS (the Communist Party of the Soviet Union) the workers of the Stalino Metallurgical Works have achieved a substantial increase in the output of pig iron, steel and rolled product in recent years. Operating in the main with the same amount of equipment as in the prewar period, the works greatly exceeded the production level of 1940. This achievement is due to the continual introduction of new techniques, the improvement of technical processes, better working conditions, and intensified creative efforts of workers and technical personnel in the plants and departments of the works.

At our works, for the first time in the world, the vaporization cooling of open-hearth furnaces, which now is being adopted at the majority of home and at many foreign works, was introduced. The blast furnaces were radically modernized; their volume was increased, most of the process was automated and the operation of the furnaces was mechanized. On one of the blast furnaces, vaporization cooling was introduced for the first time successfully. Two blast furnaces were operated at an increased top pressure and with the automatic control of blast humidity.

The blast furnace operators of our works expended a great deal of effort to improve the techniques of the pig-iron process and the methods of controlling the blast furnace operation. The blast furnace plant, the first plant in the south to do so, began the production of conversion pig iron, initially with partial and then with a complete elimination of maganese ore from the charge. It was established that the main condition for the production of low-manganese pig iron with sulfur content below 0.040% is a high basicity of the slag (not less than 1.30) and a silicon content in pig iron of not less than 0.6%. Stable primary slags are achieved by the introduction into the charge of aluminous ores (Al_2O_3 content in the slag should not be less than 7%). The consumption of dolomitized limestone should constitute about 30% of the total input of fluxes. The change-over to the production of low-maganese pig iron resulted in a 6.6% reduction in coke consumption and a substantial increase in blast furnace output. Annual savings amounted to more than 5 million rubles.

The Central Works Laboratory carried out investigations on the relationship between the CO_2 content and the radius of the shaft and the temperature of the blast furnace gases. Tests indicated that it might be possible to replace gas composition determination by temperature measurements for the control of gas flow distribution. On this basis, an experimental apparatus has been installed at No. 1 blast furnace and by means of this apparatus the distribution of gas flow in the furnace can be checked not once or twice in a shift but 15, 20 or even more times. By making use of automatic measurements of the blast furnace gas temperature in the shaft it is possible to increase the output of the blast furnace and to reduce coke consumption.

The works research group developed a radioactive level indicator of special design which allows a more frequent determination of the amount of dust in the dust-catchers without discharging the dust into dump cars. Hence, it will be possible to adjust the charge according to dust carry-out every hour and a half. At present, the level indicator is being tested under industrial conditions; instructions on how to operate the instrument and how to evaluate its readings for the adjustment of the charge are being worked out.

Many innovations were introduced in the steelmaking section of the works. In 1957, all open-hearth furnaces were converted and provided with thrust-and-suspension magnesite-chromite roofs, and the upper rows of the regenerator checkers were laid with chromite Dinas brick, which proved to be more durable than ordinary

Dinas brick. For the measurement of the temperature of the bath, immersion thermocouples are employed in all furnaces. Many improvements were introduced in the processes of making and pouring steel. Steel melters successfully mastered the production of low-carbon steels without preliminary deoxidation of the metal in the furnace, thus speeding up the process considerably and providing a saving in ferroalloys. The use of aluminum for the deoxidation of 55S2 and 18KhGT steels was discontinued and the amount of aluminum for the deoxidation of tube steels grade 10 and 20 was reduced; it was experimentally established that the reduction in the input of aluminum did not impair the quality of metal but resulted in a saving of about 15 tons of aluminum per year. The adoption of large size ingots of rimmed and killed steels resulted in a considerable reduction in the consumption of refractories and molds in the open-hearth furnace plant and made possible a 3.1% increase in the output of rolled product.

Recently, in the open-hearth and steel-rolling plants of our works, the production of new grades of steel, including 25GS low-alloy reinforcement steel for reinforced concrete constructions, was mastered. This particular steel grade is already manufactured in large quantities by several works in our country. This steel is extensively employed in reinforced concrete, resulting in savings of more than 30% of metal.

Radioactive isotopes are extensively employed at the works for the study of steelmaking processes. Recently, a study of the behavior of sulfur in the open-hearth bath was carried out by means of radioactive isotopes.

A great deal has been done in the steel rolling plants of our works with respect to modernization and new techniques. In the blooming and plate-rolling plants, new equipment, registering the amount of draft, actual rolling time, and idle intervals during steel rolling on roughing stands, was installed. In the plate-rolling plant, the roller tables conveying ingots from the furnaces to the three-high stand were automated, and several improvements were introduced in the roll housing. In the structural-steel mill the rate of rolling was increased by changing the pass design and reducing the number of passes. The adoption of a new method of rolling special section steel raised the mean output per shift and reduced the percentage of defective product in this process by a factor of 1.5. The introduction of "corrugated" rolls in the three-high mill of the plate rolling mill ensured an efficient removal of scale from the surface of plate billets, improved the quality of steel plate, and made it possible to completely discontinue the use of birch twigs in the stands.

Leading workers, innovators, and inventors, side by side with the technical personnel of the works, take part in the work on the improvement of the techniques and technology of production. Among them are Disko, a mechanic of the structural-steel mill, Dubchenko, a fitter at the blooming mill, technicians and technologists Oleksa, Kotov, Kovtorin and others. The savings resulting from innovations introduced in 1957 amounted to about 4 million rubles.

In 1958 the work on the further improvement of technical processes and on the improvement of the conditions and technical level of production is being continued. In the open-hearth section, a large commercial plant for continuous casting of steel is being built, the construction of a large thermal-treatment plant in the very near future is planned, and extensive scientific research works are being carried out at the blast furnace open-hearth and steel-rolling plants.

This issue of the "Metallurgist" is devoted mainly to the operational experience of the Stalino Metallurgical Works. Members of the Technical Department of the Works – F. N. Grigor'ev, M. A. Kamenskii and D. A. Oterin – took part in the preparation of this issue.

DAMPER EQUIPMENT FOR THE COUNTERWEIGHTS OF THE BELLS ON THE BLAST FURNACE

L. B. Brodetskii

Stalino Metallurgical Works

Until 1956, the blast furnaces of the Stalino Metallurgical Works had no equipment which would ensure the smooth operation of the counterweights of the small and large bells. Therefore the bearings of the counterweights and the supporting beams were frequently out of order. Sometimes a crosstie was placed under the counterweight in order to soften the impact. The shock-absorbing equipment proposed by the Ural Works for Heavy Machinery contributed to a marked improvement in the bell operation. We think that this equipment should be adopted on all blast furnaces.

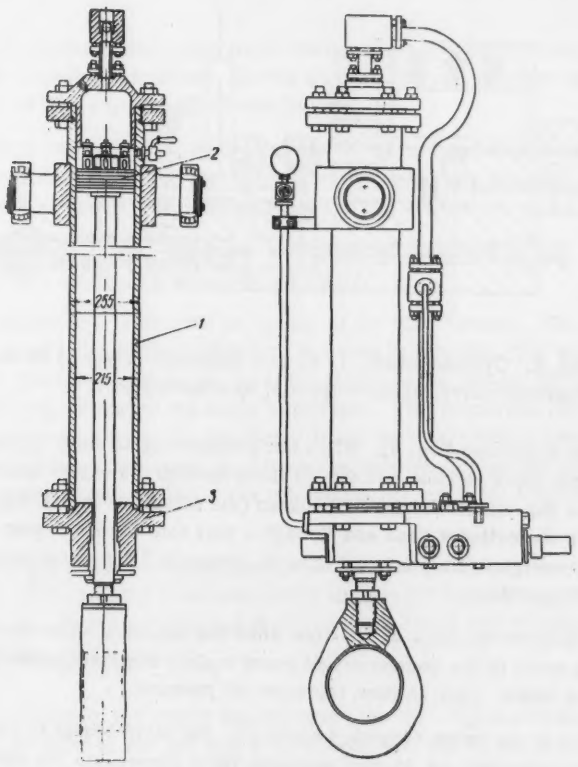


Fig. 1. Damper: 1) Cylinder; 2) piston; 3) head.

The shock-absorbing dampers for the bell counterweights protect the equipment from premature wear. The dampers provide for a smooth descent of the counterweights should the rope break or become loose at the moment when the gas mixture in the interbell space explodes. If the rope breaks the counterweight equipment is not damaged.

The counterweight of the large bell is provided with two dampers, which operate synchronously, and the counterweight of the small bell is provided with one damper.

The damper (Fig. 1) is a cylinder inside of which slides a piston with four valves. The cylinder has a steel head with two valves, one of 45-mm diameter and the other 30-mm diameter. The cylinder is filled with oil which enters through the cylinder head from an oil tank. The dampers are mounted on a cast-iron plate which can be moved by means of stop bolts and can be aligned with respect to the axis of the counterweight equipment.

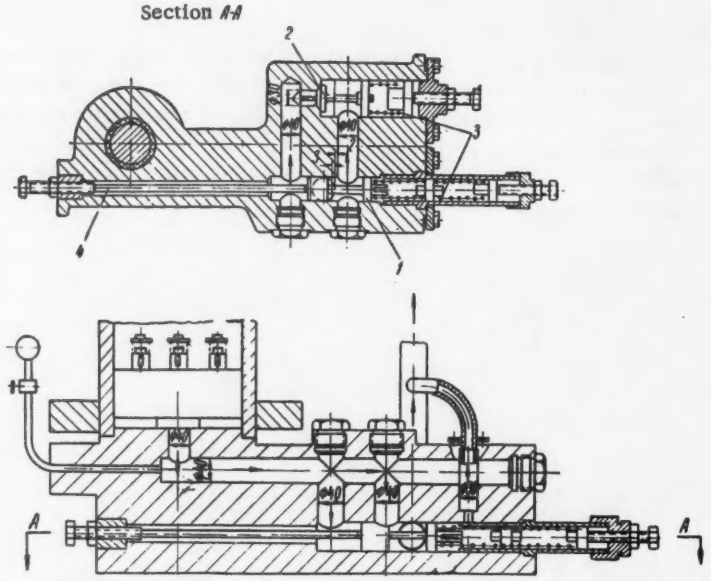


Fig. 2. Cylinder head: 1) 45-mm diameter valve; 2) 30-mm diameter valve; 3) valve springs; 4) adjusting bolt.

The dampers operate as follows (Fig. 2). When the counterweights move up, the piston in the cylinder moves from the lower to the upper position and the oil flows through the valves from the upper to the lower part of the cylinder. When the counterweights move down (the closing of the bells), the piston presses the oil out through the openings in the cylinder head and through a tube into the upper part of the cylinder. At a normal speed of the counterweights, the pressure in the oil system is 3 – 5 kg/sq cm; the 45-mm diameter valve is in the extreme left position.

If the cable breaks or becomes slack at the time when the counterweights are falling after an explosion in the interbell space, the speed of the counterweight beam rapidly increases, causing an increase in the speed of oil flow in the ducts and tubes. This, in turn, increases oil pressure.

When the oil pressure at the valve exceeds 4 kg/sq cm, the valve begins to move to the right, and when the oil pressure reaches 10 kg/sq cm, the 45-mm diameter valve moves into the extreme right position. At the same time the 40-mm diameter opening will be covered to the extent of a full stroke of the valve.

The oil has then to flow into the upper part of the cylinder through a 2 – 3 mm wide slit, and hence the descent (falling) velocity of counterweights will be reduced.

When the valve is moved to the extreme right position the pressure in the ducts in front of the valves increases up to 60 kg sq/cm. The 30-mm diameter valve then opens slightly and allows some oil to flow into the upper part of the cylinder, in this way reducing the hydraulic shock. Under the action of the spring, the 30-mm valve closes the opening again, and then the oil again flows only through the slit into the opening at the 45-mm valve and the counterweight beams descend at the specified velocity of 0.5 m/sec.

OPERATION RECORDER OF THE CHARGING EQUIPMENT OF THE BLAST FURNACE

E. I. Sametskii

Deputy head of the KIP plant of the Stalino Metallurgical Works

The carrying-out of the predetermined program of charging and the operation of the revolving distributor should be recorded by a self-recording instrument. In this way the foreman is better equipped to control the operation of the furnace and to take any necessary steps in time.

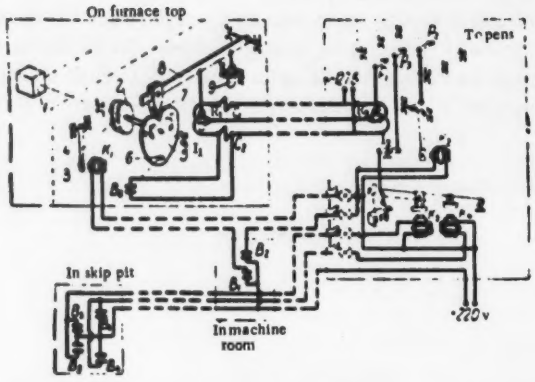
On blast furnace No. 4 of the Stalino Metallurgical Works, an instrument which records the angle of turning of the distributor with an accuracy of 1.5°, the lowering of the small and the large bell, the amount of charged ore and coke skips, and the time of the beginning and of the completion of these operations, has already been in use for one year.

The basic diagram of the equipment is shown in the figure.

A turning-angle data transmitter is situated on the top of the blast furnace. The shaped cam of the angle data transmitter is actuated by the rim of the distributor. A recess in the cam, into which a roller enters, fixes the zero position. When the distributor moves, the lever (8) displaces the plunger (R_1) of the induction bridge ($I_1 - I_2$) by distances directly proportional to the angle of rotation. This causes the movement of the plunger (R_2) and the pen (P_1) which produces a stroke on the chart. When the small bell is lowered, the switch (B_1) is closed, the coil (K_1) is switched in and the lever (4) disengages the electromagnetic clutch (2). The cam (5) returns to the zero position under its own weight. The oil dashpot (9) serves for smoothing the descent of the lever (8).

At a negative turning angle of the revolving distributor the pin (6) releases the shunt switch (B_5), thus introducing the resistance (C_2) which puts the induction bridge slightly off balance, and the pen (P_1) produces a short stroke below the zero line. In this way the pen (P_1) records the value and the sign of the turning angle, and registers the lowering of the small cone.

When the large cone is lowered, the switch (B_2) is closed, the coil (K_2) is switched in and the pen (P_2) is set in motion. When either the right or the left skip is filled with ore, one of the switches (B_3) is closed, the coil (K_3) is switched in and the pen (P_3) makes a mark on the chart. When the coke door is lifted, one of the switches (B_4) is closed and the pen (P_3) is set in motion.



Recorder of the charging equipment of the blast furnace: 1) Rim of the revolving distributor; 2) electromagnetic clutch; 3) switch; 4) lever; 5) cam of the data-transmitter; 6) pin; 7) roller; 8) lever; 9) oil dashpot; 10) instrument for registering the number of skips; B_1) small bell switch; B_2) large bell switch; B_3) ore skip switches; B_4) coke skip switches; B_5) switch of the negative turning angle of the revolving distributor; K_1-K_4) coils; R_1 and R_2) plungers; C_1 and C_2) resistances; I_1—I_2) induction bridge; L_1-L_4) lamps; P_1-P_3) pens.

When the switches (B_1—B_4) are closed, the lamps (L_1—L_4) on the KIP board light up. The foreman and the blast operator can thus watch the operation of the charging equipment.

APPLICATION OF PYRITE CINDERS IN THE PRODUCTION OF HIGH-BASICITY SINTER

L. Ia. Levin, N. M. Iakubtsiner, V. M. Sholeninov and G. F. Grigor'evykh

The Cherepovets Metallurgical Works and the Leningrad Polytechnical Institute

Since the end of 1956, at the Cherepovets Metallurgical Works pyrite cinders have been introduced into the sinter charge; the amount of pyrite cinders in the first half of 1957 amounted to 25% of the iron ore portion of the charge. The use of pyrite cinders was caused by the shortage of ore concentrate.

Until recently, in the USSR the pyrite cinders were hardly, if at all, utilized in the sinter charge at metallurgical works, although some short-term experiments on the sintering of cinders were conducted even before the war. There is no literature information on the use of cinders in the preparation of fluxed sinter of high basicity from fine concentrates. Therefore, it was necessary to carry out a series of tests on semi-industrial and industrial scales in order to determine the best conditions for sintering. As a result of the experiments,

processing conditions have been worked out under which a maximum removal of sulfur and the production of a relatively strong sinter from a charge containing a large amount of pyrite cinders are attained.

Operational Conditions at the Sinter Plant

The sinter plant is equipped with three sinter machines of 75 sq m sinter area each. The plant produces sinter of basicity $CaO/SiO_2 = 1.15 \pm 0.07$. At a relatively high content of silica (about 15%) in the main component – the ore concentrate – of the charge, more than 300 kg of limestone is used per ton of sinter. In addition, blast furnace dust is added to the charge, but its input is very small because of the low carry-out of dust in the blast furnaces.

Data on the raw materials are given in Tables 1 and 2.

TABLE 1

Chemical Composition of the Components of the Sinter Charge

Material	Content, %							
	Fe	FeO	CaO	SiO_2	Ignition losses	C	S_{total}	$S_{sulfates}$
Olenegorsk concentrate	58.95	19.17	1.13	14.54	—	—	0.016	—
Blast-furnace dust	24.04	8.60	16.36	18.30	—	16.75	0.34	—
Pyrite cinders (from the Shchelkovsk Works)	45.69	—	1.48	18.48	—	—	3.49	0.730
Limestone	—	—	51.72	2.20	41.33	—	0.056	—
Coke fines	Ash 12.85		—	—	Volatiles 2.00	84.60	0.57	—

TABLE 2

Screen Analysis of the Components of the Sinter Charge, %

Fraction, mm \ Material	Olenogorsk concentrate	Blast-furnace dust	Pyrite cinders from Shchelkovsk Works*	Limestone	Coke fines
+3.000	—	—	1.50	2.58	10.00
3.000—1.300	1.26	0.4	2.45	13.72	25.02
1.300—0.540	9.16	10.0	5.36	30.50	26.28
0.540—0.425	5.21	7.4	2.21	8.36	5.00
0.425—0.290	15.13	18.2	4.90	17.70	8.23
0.290—0.174	32.66	30.0	12.66	17.80	10.34
0.174—0.100	20.38	15.6	16.15	4.24	5.21
—0.100	16.20	18.4	54.77	5.10	9.92

* 1956 production.

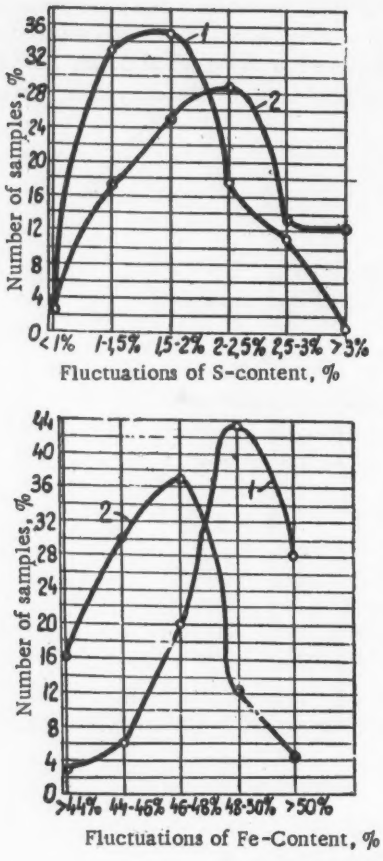


Fig. 1. Sulfur and iron content in the pyrite cinders of the Dorogomilovsk and the Shchelkovsk Chemical Works: 1) Cinders of the Dorogomilovsk Works; 2) cinders of the Shchelkovsk Works.

Later on, the iron content in the pyrite cinders somewhat increased, in particular in the pyrite cinders of the Dorogomilovsk Works (up to 48-49%), and the sulfur content was considerably lower than in the pyrite cinders of the Shchelkovsk Works (Fig. 1). Copper content in the pyrite cinders from both works constitutes 0.3-0.4%, and zinc content 0.35 – 0.45%.

Semi-Industrial Scale Tests

For the determination of the optimum operational conditions, investigations were carried out on the effect of the carbon content in the charge, the degree of basicity of the sinter, the amount of the return fines in the charge and the height of the sintered layer, on the sulfur content in the sinter, its mechanical strength, and the velocity of sintering.

The test was carried out under semi-industrial conditions in a sintering cup (Fig. 2) with 0.11 sq m (325 x 330 mm) sintering area, the cup being joined to the exhauster of the sintering machine.*

In order to eliminate the effect of any chance factors due to the variation in the quality of raw materials, constant-composition materials were prepared beforehand for the experiments. Coke fines and limestone were of 3 – 0 mm size fraction. Accidental impurities in pyrite cinders, concentrate, and blast furnace dust were separated by means of a 5-mm mesh screen. The returns were of 12 – 0 mm size. Large-size, fully sintered material was ground and used as returns so that no unsintered materials were present in the returns. The mechanical strength of the sinter was determined in a commercial type drum by the usual method.

The effect of the sinter basicity. Tests were carried out with charge calculated to produce a sinter of 1.0 – 1.2 basicity. The content of pyrite cinders in the charge was varied from 10% to 30%.

It is seen from Fig. 3 that a minimum sulfur content in the sinter is obtained when there is not more than 4.5% carbon in the charge. With the increase of carbon content in the charge above that value, the sulfur content in the sinter increases because the atmosphere becomes more reducing and the sulfide sulfur is less effectively oxidized. Furthermore; with the excess of carbon, the gas permeability of the charge decreases. This is indicated also by the lowered velocity of sintering. The maximum velocity of sintering (about 13.5 mm/min) is attained at a 4.5% carbon content in the charge, and at a higher carbon content the velocity falls (down to about 12.5 mm/min at 5%, and to about 11.5 mm/min at 5.5% carbon content).

The mechanical strength of the sinter, as determined by the drum number, increases with the increase of carbon content in the charge from 4% to 4.5%. On a further increase of the combustible content, the strength of the sinter remains at the same level or even decreases somewhat.

The tests showed that on sintering a charge which contains pyrite cinders a more accurate proportioning of combustibles should be maintained in order to reduce as much as possible any deviations from an optimum carbon content in the charge (4.5% in our experiment, 3.5-4.0% under industrial conditions). Under those conditions a maximum removal of sulfur and a mechanically strong sinter at the highest sintering velocity are attained.

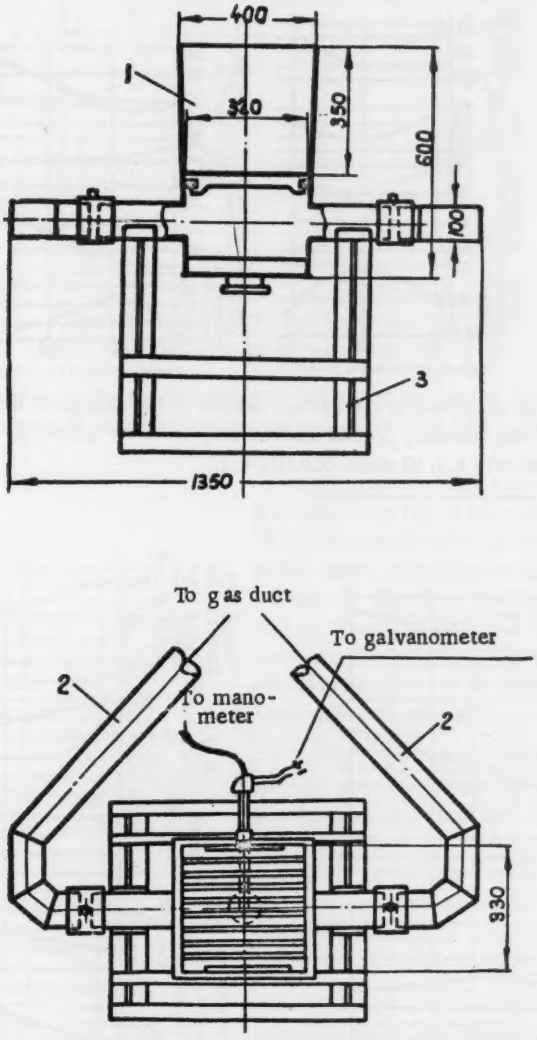


Fig. 2. Experimental sintering apparatus: 1) Cup; 2) gas take-off; 3) frame.

Tests on production of sinter of 0.5 basicity confirmed that the minimum sulfur content and the best strength is achieved at 4.5% carbon content in the charge. At a higher or lower content these results deteriorate.

In Figure 4 are shown the results collected from tests on sintering of charge which contained 33% of pyrite cinders. The sulfur content in the sinter increases with the increase of CaO, and this is explained by the presence of sulfur in the form of sulfate (20-40% of the total amount of sulfur present) in pyrite cinders. The decomposition of calcium sulfate begins at 1200°C and terminates at still higher temperatures, which cannot be attained in all layers of the charge. This is especially apparent in the production of high-basicity sinter, which sinters at relatively low temperatures. Hence when carbon content in the charge is increased a little (from 4 to 4.5%), the sulfur content in the sinter decreases. When pyrite cinders were introduced into the commercial production of sinter it was necessary to change to a somewhat higher carbon content in the charge.

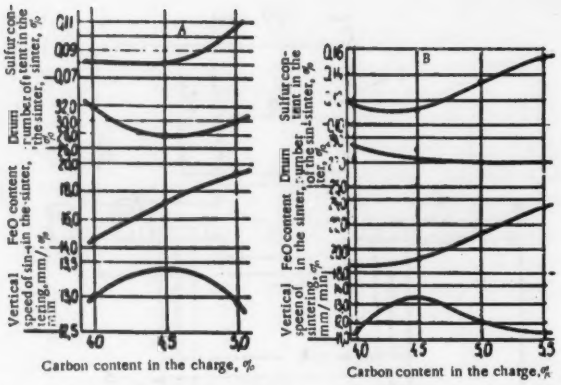

A
B
Vertical speed of sintering, mm/min
FeO content in the sinter, %
Drum number of the sinter, %
Sulfur content in the sinter, %
Carbon content in the charge, %
Carbon content in the charge, %

Fig. 3. Effect of the carbon content in the charge on the indices of the sintering process and the quality of the sinter: a) sinter basicity 1.0; b) sinter basicity 1.2.

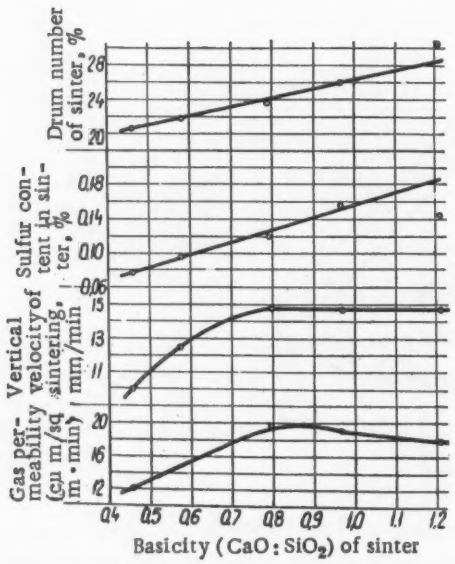

Drum number of sinter, %
Sulfur content in sinter, %
Vertical velocity of sintering, mm/min
Gas permeability (cu m/sq m · min)
Basicity (CaO : SiO2) of sinter

Fig. 4. Effect of the basicity of the sinter on the characteristics of the sintering process and on the quality of the sinter.

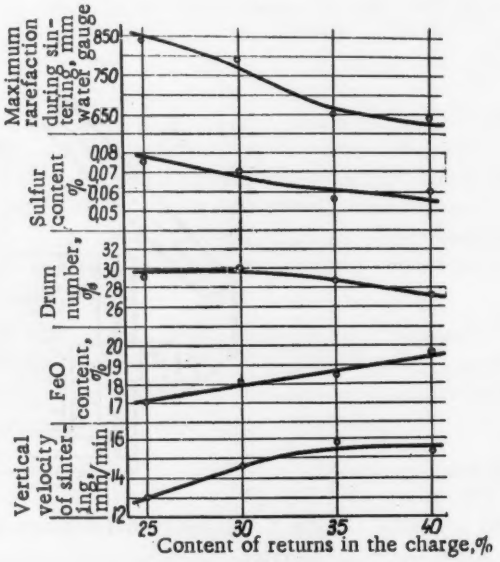

Maximum rarefaction during sintering, mm water gauge
Sulfur content %
Drum number, %
FeO content, %
Vertical velocity of sintering, mm/min
Content of returns in the charge, %

Fig. 5. Effect of the quantity of returns in the charge on the characteristics of the sintering process and on the quality of the sinter.

The velocity of sintering increases rapidly with the increase in basicity of the sinter to 0.8, but a further increase in the basicity has no effect on the velocity of sintering. The gas permeability of the charge changes in the same manner.

With the increase of sinter basicity the value of the drum number increases and, of course, the iron content decreases. In the tests, the iron content in the sinter decreased from 53 to 47% when the basicity of the sinter was changed from 0.4 to 1.2 (on account of the pyrite cinders, the iron content decreased by 2.5%).

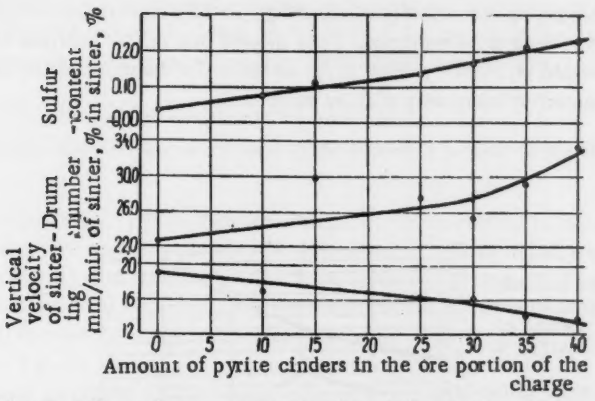


Fig. 6. Effect of the amount of pyrite cinders in the charge on the characteristics of the sintering process and the quality of the sinter.

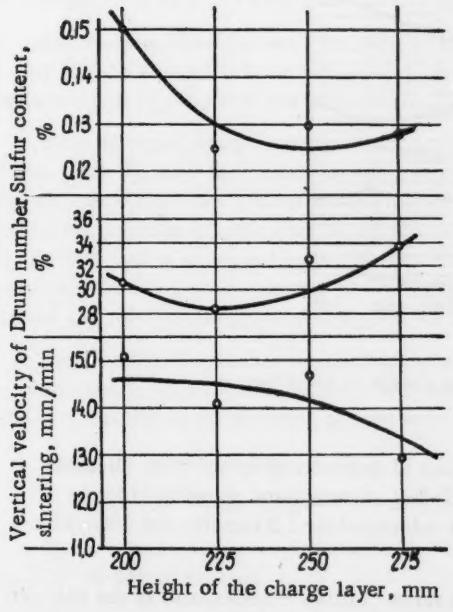


Fig. 7. Dependence of the characteristics of the sintering process and the quality of the sinter on the height of the charge layer.

The effect of the amount of returns in the charge. It is seen from Fig. 5 that the increase of returns from 25 to 35% contributes to a decrease of the sulfur content in the sinter, enhancing its mechanical strength and the velocity of sintering. The favorable effect of returns on the velocity of sintering is connected with the particular characteristics of the charge, which consists dominantly of very fine materials (ore concentrate, cinders and limestone).

The improvement in the gas permeability of the charge when the amount of returns in the charge is increased is indicated also by the value of rarefaction which represents the resistance to the gas passage. Maximum rarefaction constituted 850 mm of water in the sintering of charge which contained 25% of returns, but at 35% of returns (other conditions being equal) maximum rarefaction did not exceed 650 mm of water.

However, the favorable effect of returns is apparent only up to 35% content of returns in the charge. A further addition of returns shows no advantages so far as a lowering of the sulfur content or an improvement in the mechanical strength of the sinter are concerned.

The effect of the quantity of pyrite cinders in the charge. The addition of pyrite cinders (Fig. 6) causes an increase in the sulfur content in the sinter. In our tests, the sinter contained less than 0.1% sulfur when 15-16% of pyrite cinders was added. The addition of 25% cinders to the charge causes an increase of the sulfur content in the sinter to 0.13%, and with 35-40% of cinders in the charge, the sulfur content in the sinter increases to 0.2-0.23%.

In industrial conditions, at 20% pyrite cinders in the charge the amount of sulfur in the sinter constitutes about 0.08%. The better desulfurization on sintering machines is explained by lower internal relative heat losses during sintering. Hence, less carbon may be introduced into the charge and, under certain conditions, this is conducive to a better removal of sulfur.

The drum number of the sinter also increases with the increase of the pyrite content. Sinter of drum number below 27 (acceptance limit at the Cherepovets Metallurgical Works) is produced when there is 25-27% of pyrite cinders in the charge.

The introduction of cinders lowers the velocity of sintering. At 25% cinders the velocity falls from 19 to 16.5 mm/min, and at 35-40% it falls to 14 mm/min. Tests showed that on the addition of 20-25% cinders to the charge it is possible to obtain satisfactory sinter as far as the sulfur content and the mechanical strength are concerned, the velocity of sintering being only slightly decreased.

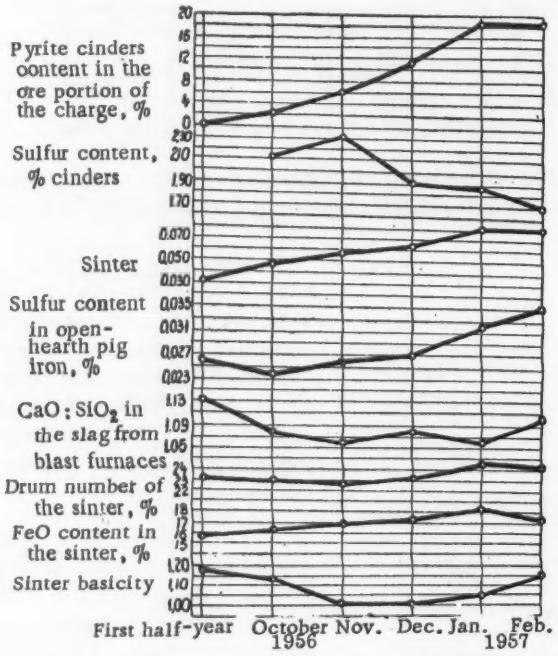


Fig. 8. Application of pyrite cinders in the sinter charge at the sinter plant of the Cherepovets Works.

The effect of the thickness of the charge layer. With the object of determining an optimum thickness of the charge layer for the sintering process with the use of pyrite cinders, experimental sintering of layers 200, 225, 250 and 275 mm thick were carried out. The charge was calculated for 1.2 basicity and 25% pyrite content.

It is seen from Fig. 7 that the maximum sulfur content in the sinter – 0.15% – corresponds to the 200-mm layer. The increase of layer thickness to 225 mm assists in desulfurization. However, a further increase in layer thickness results in an increase of sulfur content in the sinter. A medium-high layer proved to be optimum (with regard to the conditions of desulfurization in our experiments). As earlier experiments showed, when a thin (200 mm), highly permeable layer is employed, the sintering takes place at low temperatures, as the gases pass quickly through the charge and there is no time for the transfer of their physical heat to the materials in the charge.

The desulfurization deteriorates under these conditions because of the low temperature of the process. At a very great thickness of the layer (275 mm) the desulfurization deteriorates because of the decreased gas permeability of the charge. A sulfur-containing charge is most effectively sintered in a 225-250 mm layer. The effect of the height of the charge layer on the mechanical strength of the sinter can be explained in the

same way. It is seen from Fig. 7 that the lowest drum number (28.4%) in the tests is obtained for a 225-mm high layer. For either higher or lower layers, the drum number is larger.

The velocity of sintering decreases as the thickness of the layer increases. It falls extremely sharply for the layer of more than 250 mm thickness. Thus, on the basis of the results of the tests, the optimum thickness of sulfur-containing charge for sinter manufacture was determined as being 250 mm.

The Application of Cinders at the Sinter Plant

The operating indices when cinders were used in the sintering process at the sinter plant are shown in Fig. 8.

On the introduction of 20% of pyrites into the charge, the sulfur content in the sinter increases from 0.034% to 0.080%. In the course of the sintering process, 70-80% of sulfur is removed, whereas during the sintering of sulfide ores, e.g. Magnitogorsk ores, over 95% sulfur is removed by burning. The inefficient sulfur removal is explained by the fact that pyrite cinders contain sulfate sulfur, which is difficult to remove during the sintering of charge with high CaO content (16-17%). However, till January, 1957, the sulfur content in pig iron did not increase (as is seen from Fig. 8), and it remained within the limits of 0.024-0.027%. Only after the amount of pyrites was substantially increased did the sulfur content in pig iron rise to 0.035%. As, however, in the same period there was also a higher sulfur content in coke (Donets coal in the amount of 10% was added to the coal charge), the effect of pyrite cinders on the sulfur content in pig iron was very slight. The basicity of the slag did not increase when cinders were used.

The mechanical strength of the sinter after the introduction of cinders decreased slightly; the drum number changed from 23.2 to 24.5% and the 0 – 5 mm fraction in the sinter constituted 6.0 – 6.5%.

Calculations show that with the addition of about 20% cinders to the charge, the iron content in the sinter falls by 2%, the amount of blast furnace slag increases by 72 kg per ton of pig iron, and the coke consumption increases by 18 kg per ton of pig iron.

When sintering charge contains 20-25% of pyrites, the reduction in the iron content in the sinter constitutes about 2%, and this should have an effect on the coke consumption and the efficiency of blast furnaces. However, the operational indices of the blast furnaces did not deteriorate; during the period under consideration the consumption of coke was 700 kg per ton of pig iron, and the coefficient of furnace volume utilization – – 0.73. This fact is explained by the use made of available potentialities for intensifying the blast furnace process and reducing coke consumption, i.e., the increase in the furnace gas pressure, the improvement of the physical and mechanical properties of coke, an increase in the temperature of the blast, etc.

Tests on sintering cinder-containing charge on commercial sintering machines, in the main, confirmed the results obtained in semi-industrial scale tests. At the same time, the conditions required for a maximum sulfur removal during the sintering process were more accurately determined.

The main conditions are:

1) a reduction in the height of the sintered layer to 240-250 mm from 275 mm;

2) an increase of the carbon content in the charge from 3.5-4% to 4.5-4.8% on the introduction into the charge of 20-25% of cinders;

3) good gas permeability of the charge, attainable by increasing the content of returns to 30-35% in the charge and by the formation of a sufficiently high artificial bed.

To prevent a sudden increase in the sulfur content in the sinter, the pyrite cinders were blended in storage before delivery to the sinter charge.

It must not, however, be forgotten that, as a result of cinders being used, the charge of the blast furnaces has a lower iron content. Therefore, pyrite cinders should be enriched before being used in the sintering process. It is necessary to find an effective and inexpensive method of cinder enrichment.

REDUCING THE AMOUNT OF ALUMINUM FOR THE DEOXIDATION OF STEEL

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Stalino Metallurgical Works

It is known that aluminum is the most effective of the deoxidants usually employed in steelmaking. As a rule, the quantity of aluminum required for the deoxidation is determined empirically and depends on the steel grade and on the method of production. The determined quantity of aluminum added should ensure such a complete deoxidation as to prevent the appearance of blisters and cracks.

At the Stalino Metallurgical Works steel is made in 130-ton, high thermal-capacity furnaces with magnesite-chromite roofs, and is bottom-poured into 3.4-ton ingots. Standard specifications, given in the technological instructions, recommended the use of 1.0 kg of aluminum per ton of steel for the deoxidation of grade 10 tube steel and 0.7 kg per ton for grade 20 steel.

According to data in the literature there is a certain "critical" content of aluminum in the deoxidation of carbon steel. If the aluminum content is below or above the "critical" value the plastic properties of the steel are improved, and crack and fissure defects are reduced.

For the determination of the optimum quantity of aluminum to be added into the ladle, the following formulae are recommended:

for steel which does not undergo welding processes,

$$Al = \frac{0.006}{[C]}\ \%; \qquad (1)$$

for steel undergoing welding processes,

$$Al = \frac{0.01}{[C]} + 0.035\ \%. \qquad (2)$$

Calculations according to the formulae give the following results for low-carbon tube steels of grades 10 and 20:

Steel grade	Aluminum input, kg/ton		Actual input, kg/ton
	from formula (1)	from formula (2)	
10	0.6	1.35	1.0
20	0.3	0.85	0.7

Calculations according to the formula (1) give values which are obviously low, in particular for grade 20 steel. The available experimental and theoretical data indicate that it is possible to use a somewhat smaller amount of aluminum than that actually used for the deoxidation of tube steels, grades 10 and 20.

TABLE 1

Comparison Data on the Defects in Tube Steel, Grades 10 and 20, Deoxidized with Different Quantities of Aluminum

Steel grade	Aluminum input, kg/t	Accepted material cast, t	Defective material, defects being revealed in the first processing stage, % of total steel cast				
			cracks	fissures	sand blisters	macrodefects	total
10	1.0	14853	0.15	0.15	0.08	0.14	0.48
	0.7	6125	0.13	0.16	0.07	0.08	0.44
20	0.7	9129	0.20	0.29	0.05	0.14	0.68
	0.6	5520	0.20	0.20	0.05	0.06	0.58

TABLE 2

Results of Macroanalysis of Samples of Bars A and O

Steel grade	Aluminum input, kg/t	Samples A			Samples O		
		No. of samples inspected	rejected		No. of samples inspected	rejected	
			samples	%		samples	%
10	1.0	635	56	8.8	849	166	19.5
	0.7	315	13	4.1	194	21	10.8
20	0.7	129	7	5.4	52	28	54.0
	0.6	200	18	9.0	—	—	—
Mean for two grades	Usual reduced	764	63	8.25	901	194	21.5
		515	31	6.03	194	21	10.8

TABLE 3

Rejected Samples of Bar O Owing to Surface Defects in Different Methods of Deoxidizing Tube Steel

Deoxidant	Input, kg/t	Number of heats	Number of samples		
			inspected	rejected owing to surface defects	
				No.	%
Aluminum	0.6	4	40	33	82.5
Ferrotitanium	2.0—3.0	4	66	23	35.0
Silicocalcium	2.5—3.0	5	36	8	22.2

At the works the effect of reducing the amount of aluminum to 0.7 kg/ton (from 1 kg/ton for grade 10 steel) and to 0.6 kg/ton (from 0.7) for grade 20 steel was investigated.

The reduction in aluminum input had a positive effect on steel pouring; the metal became less viscous, and on filling the mold the "skin" appeared at a later stage.

A comparison of the surface quality and the macrostructure of the metal from heats in which a reduced quantity of aluminum is used with those produced in the usual manner (Table 1) shows that the total defective material in the first processing stage due to surface and macrostructure defects was somewhat lower for the heats with a reduced amount of aluminum than for the heats where the usual amount of aluminum was used. Defects of cracks and fissures vary only slightly; sand blister defects remain the same, and the defects in macrostructure are greatly reduced.

At the same time, the analysis of the heats showed that the reduction in the amount of aluminum did not make the removal of defects on the rolled material more difficult.

Out of 93 experimental heats carried out with tube steel grades 10 and 20, rolled material from 9 heats had an increased amount of rejects (more than 1.5 tons per heat). Study of the records of the heats showed that the cause of an increased defectiveness of the material was violations of the established procedure – too high temperature and quick pouring of metal.

If we exclude heats which were not poured in accordance with the established procedure, it then becomes apparent that the reduction in the amount of aluminum resulted in the reduction of rejected material with crack and fissure defects. This is in agreement with the experimental results of V. A. Efimov, who established that the crack and fissure defects in the grade 10 tube steel are at the minimum when, for the deoxidation of steel, aluminum is used in the amounts of 0.7 and 1.0 kg/ton.

The results of the macroanalysis of the heats deoxidized with the usual and with the reduced quantity of aluminum are given in Table 2.

The main defects in macrostructure are scabs, which are found by the macroanalysis of rods from the under-top part A and the bottom part O of the ingot.

The negative effect of deoxidation with aluminum on the quality of steel is, to a certain extent, confirmed by the experimental results given in Table 3, from which it is seen that the substitution of ferrotitanium or silico-calcium for aluminum results in a reduction in scab defects.

The results obtained from experimental heats as well as the results of the macroanalysis of heats in current production show that, with the reduction of aluminum input for deoxidation, the amount of rejected samples of rods A and O due to scab defects decreases.

Thus, a reduction in the amount of aluminum has a beneficial effect on the quality of metal. In accordance with the results obtained in the investigation carried out, the quantities of 0.7 kg/ton of aluminum for the deoxidation of tube steel grade 10, and of 0.6 kg/ton for steel grade 20, were established.

INCREASING THE WEIGHT OF THE INGOT

A. M. Ofengenden

Stalino Metallurgical Works

It is known that one of the potential sources of output increase of steel rolling mills is an increase in ingot weight, and this is also very advantageous for open-hearth furnace plants. When a new ingot is adopted the following conditions must be observed: a) a good quality surface and sound internal structure of the ingot and of the rolled piece; b) the minimum trimming of top and bottom parts of the ingot for a satisfactory quality of rolled metal; c) the maximum output of the blooming mill and minimum loss of metal in cutting rolled pieces; d) the minimum consumption of cast iron for molds per ton of steel produced.

At the Stalino Metallurgical Works, steel is bottom-poured into molds, six being placed on one bottom plate. In the post-war years the weight of the ingot was increased on two occasions, and in all it was raised from 2.8 tons to 3.4 tons. On the first increase of ingot weight to 3.1 tons the dimensions of the ingot – the cross section and the height – were increased but the form of the ingot (square with convex sides) was retained.

Killed-steel ingot of 3.4 ton weight. The starting point for the solution of the problem of increasing the weight of the ingot was the premise that, for the existing types of rolled material, the most acceptable ingot was 3.4 tons from the point of view of minimum metal losses as well as of the technical capabilities of the blooming mill. The increase in the weight of the ingot from 3.1 to 3.4 tons could not, however, be effected by increasing its dimensions alone, as they were limited by the construction of rolls and by the depth of the soaking pits. Calculations showed that by increasing the ingot height by 60 mm (from 1530 mm to 1590 mm) and the width by 10 mm (from 565 mm to 575 mm) the weight of the ingot could be increased only by 150 kg. Therefore, the design cross section was enlarged, compared with the 3.1 ton ingot, by changing the shape of the sides from convex to flat. This resulted in an additional 150 kg weight increase.

The main features of the mold design for the new ingot of killed steel (Fig. 1) are as follows:

The hot top is designed in such a way as to contain, on the average, about 12% of the total ingot weight. As the amount of top trimming (14% and 15%) is retained, the design shown ensures the removal (in the top trimming) of the surface and macrostructural defects where the hot top and the mold join, and prevents the metal of the hot top from getting into the material for rolling.

The internal width of the hot top is made equal to the internal width of the mold, so that the probability of skin turning when metal is entering the hot top is reduced. The mold walls are made thinner at the edges (95 mm compared with 115 mm at the sides), the object being a more uniform cooling of the ingot. The ingot has a taper of 4.08%; the ratio of the height to the mean width H : D = 2.98.

The lower base of the new ingot is made the same as in the mold for the 3.1 ton ingot, so that the existing cast iron equipment (bottom plates and loads) and the lining brick for the fountains can be used.

The rolling of the new ingot in the blooming mill (900 mm roll diameter) required some increase in the distance between rolls and slight changes in roll design; the depth of the groove in the first pass was increased by 10 mm and the width by 39 mm.

The new-type ingots, just as the old-type ones, were rolled in 15-17 passes. According to the time study carried out during the rolling of 38 experimental ingots, the change-over from the 3.1 ton ingot to the 3.4 ton one resulted in a 5.1% increase in the average hourly output of the blooming mill. Actual average production increase in a year was 3.1%, according to the reports.

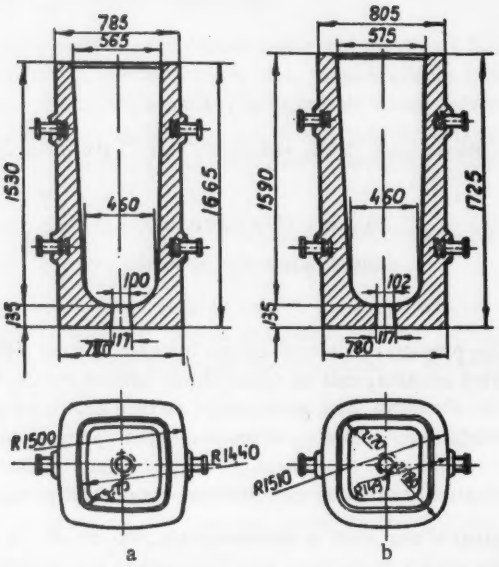


Fig. 1. Molds for killed-steel ingot: a) 3.1 ton weight; b) 3.4 ton weight.

The quality of the surface of the ingot of the finished rolled product. When low-carbon steel, grades 10 and 20, was cast into the 3.1 ton ingot with convex sides, the ingots were frequently affected by deep longitudinal cracks on the edges. No ingots with longitudinal cracks were detected in the last two years after the switch-over to the new-type 3.4 ton ingot with flat sides.

The importance of the radius of curvature of the edges of the ingot must be stressed. During the testing, a few molds were made with a larger radius of the rounded-off edges (125 mm instead of 70 mm at the top and 70 mm instead of 40 mm at the bottom). The ingots obtained from these molds were affected by deep longitudinal cracks at the edges; out of 84 ingots inspected when cold, 17 had longitudinal cracks. Hence, a larger radius of the rounded-off edges is conducive to the appearance of longitudinal cracks at the edges. The optimum radius of curvature should be approximately equal to 0.12 of the ingot width. A smaller radius of curvature is not advisable because of the risk of "burning" the corners of the ingot during the heating for rolling.

Comparative Data on Defective Metal Rolled from Ingots of 3.4 Ton and 3.1 Ton Weight

Steel grade	Weight of ingot, ton	Number of heats	Accepted rolled product, ton	Material rejected due to metallurgical defects, %		
				total	including	
					cracks	fissures
D	3.4	31	3071	0.78	0.03	0.43
D	3.1	30	2996	1.07	0.10	0.60
20T	3.4	25	2389	1.73	0.24	0.57
20T	3.1	17	1562	2.05	0.62	0.77

The change-over to the new type ingot was conducive to a reduction in the crack and fissure defects of rolled metal and hence a decrease in the amount of rejected material due to defects of metallurgical origin.

It is seen from the data given in the table that the ingots with flat sides, and the rolled product from them, are less affected by crack and fissure defects than the ingots with convex sides.

Macrostructure of the ingot and of rolled metal. The amount of metal in the hot top, determined from the difference between the total weight of the ingot and the weight of the ingot without the hot top, constituted, on the average, about 12% of the ingot weight. The macroimprints of longitudinal and lateral cross sections of medium and low-carbon steel showed that such an amount of metal in the hot top is adequate for concentrating the pipe and the shrinkage porosity in the hot top of the ingot. Moreover, there is still a layer of sound metal, not less than 35 mm thick, in the hot top. Fig. 2 shows that the macrostructure of the lateral section of an ingot of steel, grade 45, at the place where the hot top joins the body of the ingot, is quite satisfactory – there is no sign of shrinkage or shrinkage porosity.

It was established by the macroanalysis of longitudinal sections of the top ends of 9 experimental ingots that there was 0.2%-3.1% of sound metal when the end trimming was 14%. This should provide an adequate safeguard against macrostructure defects getting into the rolled material. Macroanalysis of cross-sectional samples A(under-top part) showed that the hot top which constituted on the average about 12% of the ingot weight ensured the removal of macrostructure defects with the top trimming. The macrostructure of the new and old type ingot is sufficiently sound and uniform and exhibits a relatively slightly developed segregation in the center and outside the center.

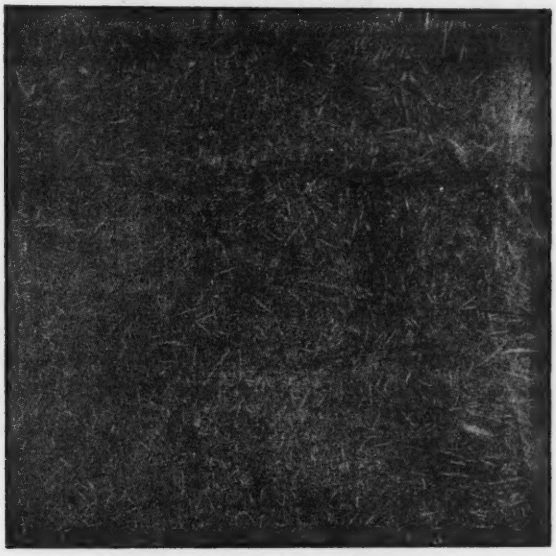


Fig. 2. Macrostructure of the cross section of the ingot at the point where the hot top joins the body of the ingot (Steel 45).

Rimmed-steel ingot. After the introduction of the mold for the new type ingot of killed steel, the mold for the 3.4 ton ingot of rimmed steel, to replace the 3.1 ton one, was designed.

The ingot weight was increased by enlarging the width of the ingot by 25 mm (from 540 mm to 565 mm at the base) and making the ingot of square form with parallel instead of convex sides (Fig. 3).

The introduction of the new-type ingot of rimmed steel into production was much easier, as the necessary conditions were already provided for in the open-hearth plant, as well as in the rolling plant, in the course of the introduction of the ingot of killed steel. Tests showed that the quality of the new type ingot of rimmed steel – like the ingot of killed steel – was very good.

The durability and consumption of molds. The life of molds for the new type 3.4 ton ingot of killed steel was found to be not lower than the life of molds for the 3.1 ton ingot and amounted to 44 heats. At the same time the consumption of molds per 1 ton of steel decreased by 3.7 kg, as the new type mold weighs less than the old type one. Hence the change in the design of the mold for killed steel was fully justified.

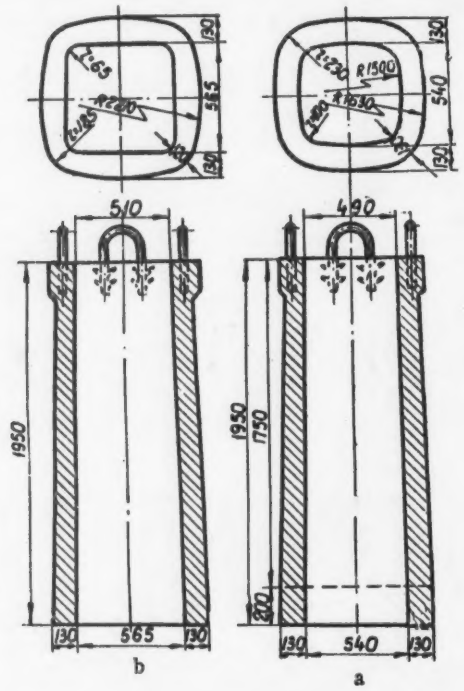


Fig. 3. Molds for rimmed-steel ingot: a) 3.1 ton weight; b) 3.4 ton weight.

Technical and economical effects of ingot weight increase. Analysis and calculations showed that increased weight of ingot resulted in a considerable reduction in mold consumption; savings were made in refractories for bottom plates because of the smaller number of molds required for one heat, and the output of the blooming mill increased.

THE LARGEST PLANT IN THE WORLD FOR CONTINUOUS STEEL CASTING

Engineers V. V. Fulmakht, E. M. Kan and A. G. Chumichev

The Central Scientific Research Institute of the Ferrous Industry

The resolutions of the 20th Congress of the Communist Party of the Soviet Union envisage an extensive introduction of continuous steel casting in the steel industry. The State Institute for the design of metallurgical works (Giprostal), in conjunction with the Central Scientific Research Institute of the Ferrous Industry, has developed a design for a four-machine plant for continuous steel casting.

The erection of this plant has already been started in the open-hearth section of the Stalino Metallurgical Works. The plant will be used for casting carbon and low-alloy steels from 140-ton ladles in four streams simultaneously. The design allows for the casting of slabs of various cross sections, varying in thickness from 120 mm to 250 mm and in width from 600 mm to 1200 mm, the speed of casting being 0.6 – 1.2 m/min. The continuous-steel-casting equipment is arranged along the columns of the casting and the stripping bays in the open-hearth section in such a way that the crystallizers are in the casting bay of the section and the delivery of billets takes place in the stripping bay.

Because of the soil conditions and the necessity for an uninterrupted operation of open-hearth furnaces, the method of mine cutting and facing with reinforced concrete tubing was selected for the construction of the shaft of the plant.

All the equipment of the plant, consisting of four independently operated machines, is situated in a circular shaft of 25 m diameter. The casting platform is 3 m above the level of the open-hearth plant floor and the bottom of the shaft is 24 m below the floor.

On the casting platform there are four intermediate pouring ladles of 14 ton capacity each, mounted on hydraulic lifting-and-turning tables; two of the intermediate ladles are working ladles and are placed above the crystallizers, and two are spare. The lifting-and-turning tables are so constructed that the intermediate ladles can be quickly changed and the steel from the next heat can be cast immediately after the casting of the preceding heat is finished.

Steel from the two intermediate ladles passes through two nozzles in each ladle (the stopper assemblies being operated hydraulically) into four crystallizers. The crystallizers are of an assembled construction and consist of four separate walls which, in turn, are constructed of two plates; internal – copper, and external – cast iron plate. Between the plates there are longitudinal channels for cooling water, which cools the copper plates during the casting operation.

For each section of the cast ingot, the crystallizers are assembled in a special framework. The frameworks are of universal construction so that crystallizers of different cross section can be assembled in the framework. A prepared framework with a crystallizer can be rapidly and easily installed in any of the casting machines. At the time of casting, the internal walls of the crystallizers are automatically lubricated by means of a special apparatus mounted on the top end of the crystallizer.

Before the commencement of the pouring, an insert, which serves as a temporary bottom, is introduced from below into each crystallizer. The insert consists of three parts of 13,800 mm total length, and in its cross section corresponds to the cast ingot. The top end of the insert, which has the shape of a swallow tail with a small gap, enters the crystallizer; at that time the lower end of the insert is fastened by the rolls of a pulling

stand. When casting begins, the rolls of the pulling stand start to lower the insert and pull the ingot from the crystallizer. After the insert leaves the pulling stand, each part of the insert is automatically detached and is removed by special truck to a place under the platform, 17.350 m below the plant floor. When the equipment is prepared for the next heat, the three parts of the insert are, in turn, put into a machine where they are automatically attached to each other and then are introduced into the crystallizer from below by means of the pulling stand.

After leaving the crystallizer, the ingot enters the zone of secondary cooling. There are guiding rollers on the section between the crystallizer and the pulling stand and they form a shaft enclosing the perimeter of the ingot. The whole section of the guiding rollers is 10.5 m long and is split into two parts – lower and upper. Each part consists of a stationary frame inside which are mounted movable frames with rollers, 140 mm x 1200 mm. The adjustment of the movable frames with the guiding rollers to a required size of the ingot is effected by electric motors and gears.

In the zone of the guiding rollers the ingots are cooled by water sprayed from nozzles mounted in the gaps between the rollers. The rate of cooling water for ingot spraying is controlled automatically, depending on the requirement of a particular casting operation, from the control desk of the casting plant. The total length of the secondary cooling is such that when the ingot approaches the pulling stand its core is fully solidified.

After leaving the secondary cooling zone, the ingot comes to the pulling stand, which serves for pulling cast ingots at a predetermined speed and for the delivery of the inserts into the crystallizer. The slabs are supported in the pulling stand by two pairs of "floating" hollow rolls which are water cooled and mounted on roller bearings. The rolls grip the ingot, which passes between them, at a predetermined pressure and prevent the slippage of the cast column of metal.

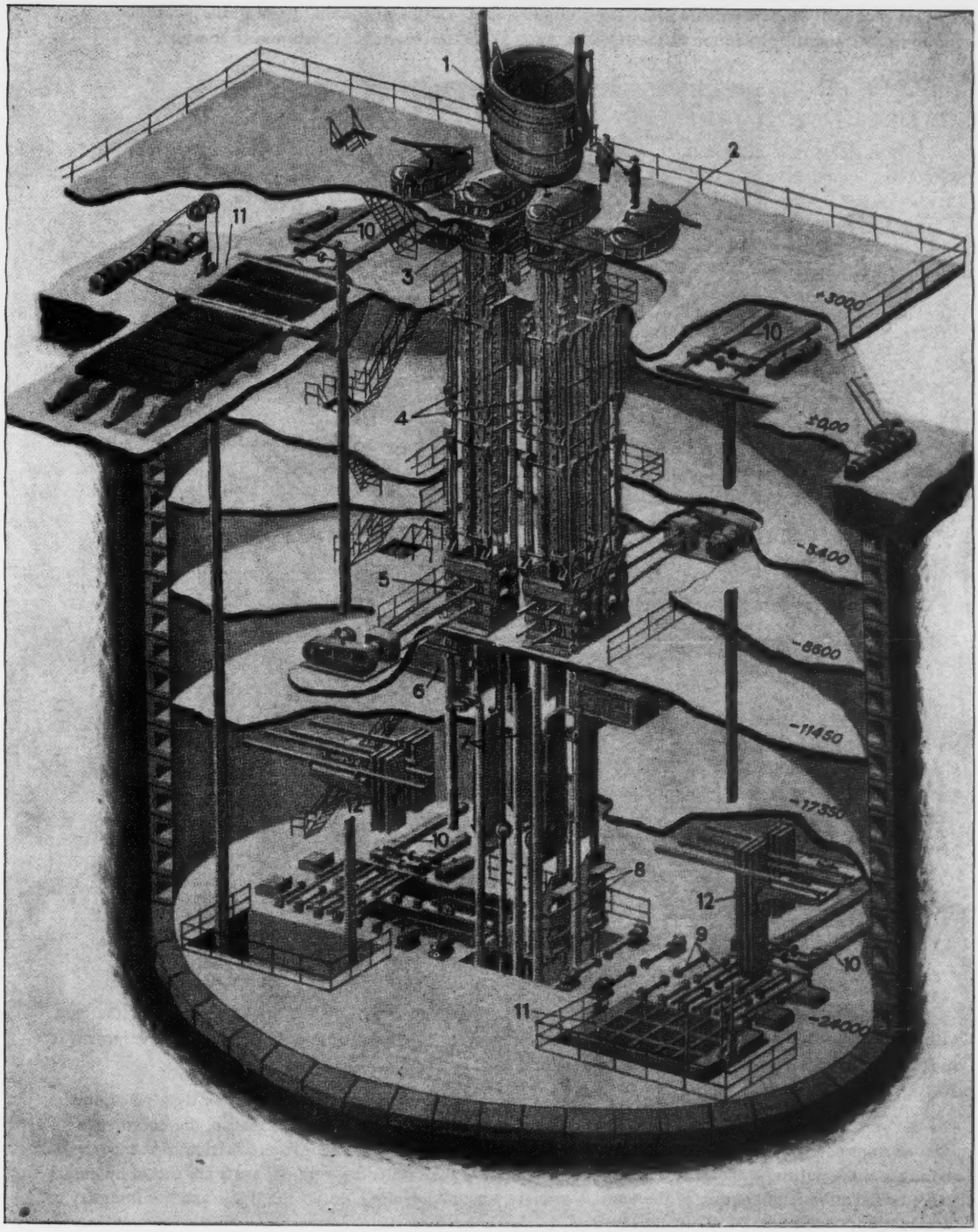
A gas cutting machine for cutting the ingot into slabs 4.2 m – 5.2 m long, in the course of the casting process, is situated under the pulling stand. The gas-cutting machine consists of a gripping attachment, a mechanism for moving the cutting torches, and the torches themselves with the necessary equipment. The gas-cutting machine is attached by two pull chains to the hydraulic drive which counterbalances and moves the machine along two guides in the vertical plane at the velocity of casting when moving downward and at a velocity of 0.3 m/sec upward.

Before the cutting, the gripping mechanism of the cutting machine grips the slab and the gas cutting machine begins to move downward at the velocity of the ingot. The cutting operation is carried out by two torches moving toward each other. After the ingot is cut, the cutting torches return to the original position for the next operation and the gas cutting machine is detached from the ingot and returned to the original upper position.

When the cutting of the next slab begins, a cross support is moved under the bottom end of the ingot and it supports the slab that is being cut off. When the slab is cut off, the cross support, actuated by the hydraulic drive, lowers it smoothly and transfers it to the tilter which places the slab on the roller tables.

At the end of the delivery roller tables, two slabs are transferred by means of a pusher from the roller tables onto the platform of a vertical hoist of 16-ton lifting capacity. There are two such hoists, one for each of the two casting machines. The hoist delivers the slabs from the shaft to the level of the plant floor, where they are transferred by the pusher onto the delivery roller tables. The underground space, i.e., the shaft of the plant for continuous steel casting is divided horizontally by ceiling platforms on which various equipment is placed. Vertical partitions separate the hot space, in which the ingots are moving, from the cold space, where driving gears and apparatus are installed. Ladders and an elevator serve for communication between the floors.

All the operations in the plant are mechanized and automated. In the course of casting, the operation of the plant, except for the gas cutting machines, is effected from the control desk on the casting platform. The control desks of the gas cutting machines are situated on the platform 17.350 m below the floor level. The control desks on the casting platform provide for an independent control of each of the four casting machines of the plant. On the control desks there are also indicating instruments, and the installation of television screens for the remote supervision of plant operations is planned. Two control panels on the casting platform comprise the required indicating and recording instruments. On the intermediate platform are also several panels with indicating and recording instruments for individual sections of the machines and other plant equipment. Communication between the main operator and the operating personnel is maintained via a two-way loudspeaker system.



The plant for the continuous casting of steel at the Stalino Metallurgical Works: 1) molten steel ladle; 2) intermediate ladle; 3) crystallizers; 4) secondary cooling system; 5) pulling stand; 6) gas cutting machine; 7) receiving clamp; 8) tilter; 9) delivery roller tables; 10) pusher; 11) hoist platform; 12) inserts.

A model of the four-stream plant for continuous steel casting at the Stalino Metallurgical Works, as shown in the Metallurgy Section of the USSR Pavilion at the International Exhibition in Brussels.

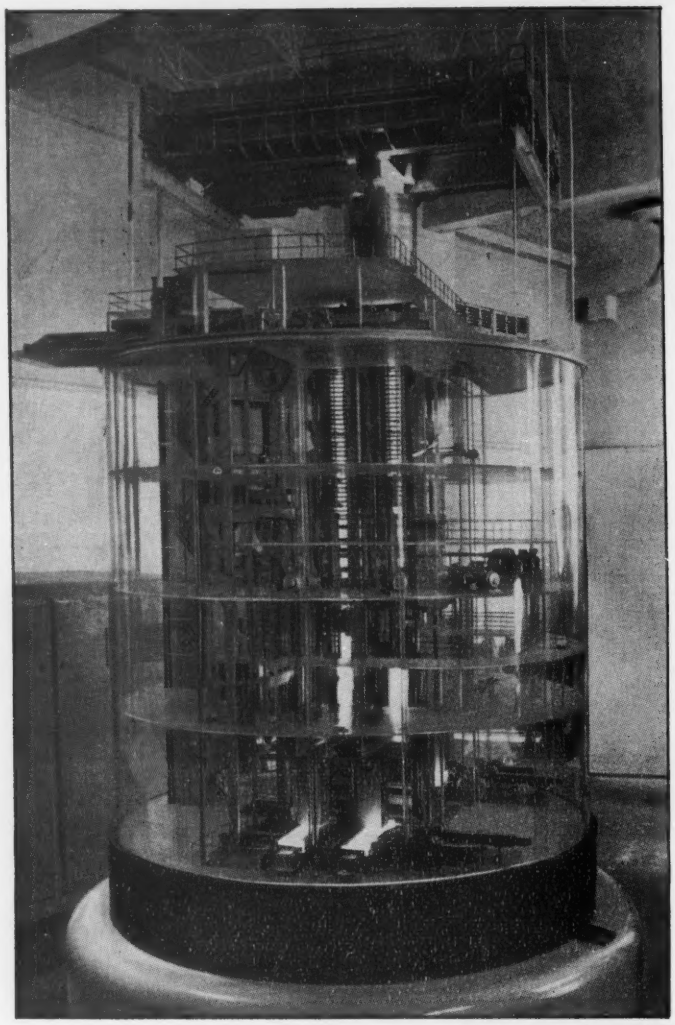


Photo I. Ia. Tsesarskii

The model is made of lucite and brass; it is 1/20 of the actual size and is 3 m high including the base. All the mechanisms of the production line and of the removal of ingots are shown; the auxiliary equipment is omitted. The mechanisms in the model are stationary.

The technique of the process of four-stream casting is demonstrated in the model by lighting effects. The delivery of the ladle with the steel to the plant, the filling of the intermediate ladle, the commencement of steel pouring into the crystallizers, the movement of the formed ingot in the section of secondary cooling and the pulling stands, the cutting of the ingots and their delivery from the shaft are shown by means of the consecutive illumination of the units, a gradual changing of the color of the lights and the intensity of illumination.

According to press reports from Brussels, this model attracts the largest number of technical specialists out of those who visit the Metallurgy Section of the USSR Pavilion.

According to the design calculations the annual economy resulting from the change from,the conventional to the new method of casting will amount to 9.4 million rubles.

OPERATION OF OPEN-HEARTH FURNACES WITH THE WASTE-HEAT BOILER

D. E. Krasnozhen and G. I. Moiseevich

Stalino Metallurgical Works

At the Stalino Metallurgical Works, four coil-type waste-heat boilers, of 570 sq m heating area each, have been installed behind four open-hearth furnaces. For the first time in the Soviet Union, the rollers were erected in a block system, i.e., all the waste-heat boilers operate not with individual separator tanks but with a common drum separator and a common steam superheater.

Operational experience has shown that with the utilization of the heat of the furnace flue gases for steam generation, waste-heat boilers make it possible – if the equipment is properly chosen – to boost the thermal capacity of furnaces. The deciding factor is the capacity of the flue-exhaust equipment.

Waste-heat boilers operate on the principle of forced circulation, special circulating pumps being used (Fig. 1).

The distribution of water to the boilers and to the vaporization coils is attained by means of discs. The steam generated is at 12 atm pressure and 350° of superheat.

Initially, the D-100/200 flue-gas fans made by the "Krasnyi Kotel'shchik" Works were installed at the first two boilers and were in operation during two campaigns. In the very first operation it was found that these fans were unsuitable for operation under the actual conditions obtained. The waste-heat boiler, as well as the flue-gas fan was of lower capacity than required and therefore, after they were put into operation, the total draft of the furnace not only showed no increase but even fell by 5 mm – 7 mm of water (Table 1).

TABLE 1

Comparison of Design and Actual Mean Parameters of the Waste-Heat Boilers

Parameter	Design	Actual
Rate of flue gas, cu m/hr	29000	37000
Heat input, million kcal/hr	—	18.5
Gas temperature before the boiler, °C	500	450
Steam output of boiler, t/hr	4.9	5.0–5.5
Boiler resistance, mm of water	42	130

Under the actual conditions of operation, the waste-heat boiler offered a higher resistance than allowed for in the design, and the flue fan was not capable of establishing an adequate vacuum for these conditions.

As a temporary measure, to increase the draft and to establish normal conditions for furnace operation, the directing attachment of the gas fan and the throttle valve in the flue behind the gas fans were removed because, even when fully opened, they offered considerable resistance to the passage of the flue gas, whose rate of flow was higher than specified in the design. The draft was then regulated by means of a turning damper situated in the common flue leading to the waste-heat boiler.

After the removal of the throttle valve and the guiding attachment, the maximum vacuum in the flue increased by 13 mm of water when the furnace was operated in conjunction with the waste-heat boiler. Later on, the low-capacity D-100/200 fans were replaced by more powerful D-20 fans with the following characteristics.

Throughput at 200° C flue-gas temperature	135,000 cu m/hr
Full pressure head	390 mm of water
Electric motor power	200 kw

As a result of the flue-gas fan change, the attainable vacuum in the flue increased to 100 mm of water. To improve the circulation in the boiler, the take-off mains of 159 mm diameter were replaced by mains of 207 mm diameter, and thus the circulation resistance was greatly lowered.

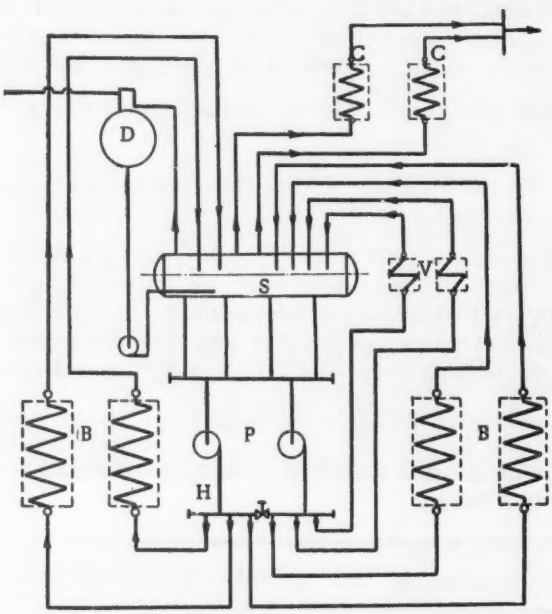


Fig. 1. Basic diagram of main tube lines of the boiler plant: S) Separator drum; D) deaerator; B) waste-heat boiler, V) vaporization coils of steam superheater, C) superheating coils; H) distribution header, P) circulation pump.

Furthermore, to eliminate discrepancies in the system, the parallel flow of the steam-water mixture in the boiler coils and of the heating gases was changed to counter-current flow; partitions were built in the header at the circulating pumps and the capacity of the deaeration equipment was increased.

Very important factors for the utilization of heat by a waste-heat boiler are the temperature of the flue gases before the boiler and the condition of the heat-transfer surface. The temperature of flue gases in the

common flue before the diversion to the waste-heat boiler was 450-550°C; the temperature of flue gases before the boiler was 400-500°C, and after the boiler it was 230 – 250°C.

During the periods of valve changes, a mixed gas of 2000-2500 kcal/cu m calorific value is forced into the flue and it fills the gas duct volume from the gas valve to the head on the switch-off side. After the combustion of this gas in the flue, the temperature of the flue gases momentarily rises to 900-1000°C; it is not, however, registered by the thermocouple, which is covered by a steel sheath.

To reduce these momentary but very high and frequent elevations of flue gas temperature, it is necessary to cut off the coke-oven gas during valve changes. The coke-oven gas cut-off by a simplified method with the application of ERV-99 electronic relays is, at present, put into practice on all furnaces.

With different periods in the course of a heat, the temperature of the flue gases varies little if the right thermal conditions in the furnace are maintained, but in some cases, during very violent reactions (during the melting period or at a high input of coke-oven gas), this temperature may rise to 700-750°C. The combustion of flue gases during valve changes and exothermic reactions in the furnace promote an increase in the mean temperature of the flue gases before the boiler, and hence improve the steam output.

At the same time, there are factors which lower the temperature of flue gases. Among these factors, first of all, are air leakages.

Considerable air leakages into the flue through the flue brickwork, as well as air escape through leakages in the "Nei"* air valves, markedly increased the amount of outgoing combustion product. It is seen from the data given in Table 2 on the composition of flue gases passing through the gas duct that the amount of flue gases increased very markedly on account of the air intake (leakages) in the section from the take-off end to the waste-heat boiler. There was some air intake in the waste-heat boiler itself due to leakages.

TABLE 2

Composition of Outgoing Flue Gases

Sampling place	Flue gas composition, %		Volume increase
	CO_2	O_2	
Take-off end	15.8	2.2	—
In front of the waste-heat boiler	9.8	9.2	1.6
After the waste-heat boiler	9.0	10.0	1.08

Air leakages lowered the output of the waste-heat boilers considerably. These conditions were especially characteristic of the early period of the operation of the waste-heat boilers.

In some cases, because of a very bad fit of the flue gas sliding damper or because of the presence of large gaps between the damper and the frame, the flue gases from the flue duct were drawn into the waste-heat boiler. The ingress of a large amount of flue gases from the flue at 200-250°C lowers the temperature and increases the volume of the gas before the waste-heat boiler. The increase in the amount of flue gases passing through the waste-heat results in a sharp increase of boiler resistance. Recirculation of the flue gases lowers the steam output of the boiler, reduces the potential draft of the furnace and puts an additional load on the electric motor of the flue-gas fan.

The temperature, pressures and composition of the flue gases in the gas duct of the No. 3 open-hearth furnace at the time when a large amount of flue gases from the flue was drawn in as a result of the poor fit of the damper are given in Fig. 2.

As a rule, the waste-heat boilers are shut down for cleaning every third day and at the end of the heat, when, owing to lower thermal requirements, there is an adequate draft even without the operation of the waste-heat boiler.

*Transliteration of Russian – Publisher's note.

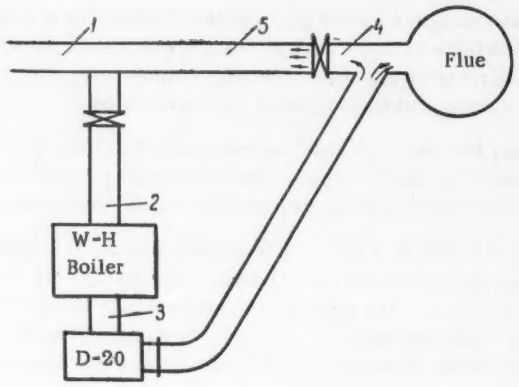


Fig. 2. Rarefaction, temperature and composition of flue gases at different points of the gas passage when a recirculation of flue gases through the flue gas damper takes place: point 1) p = −72 mm of water, t = 530°C, CO_2 = 11.0%, O_2 = 10.4%; point 2) p = −90 mm of water, t = 420°C, CO_2 = 10.8%, O_2 = 10.5%; point 3) p = −275 mm of water, t = 220°C, CO_2 = 9.9%, O_2 = 11.5%; point 4) p = −38 mm of water; point 5) p = −72 mm of water.

The change of valves at the furnaces is carried out according to the "counter gas" scheme, with a minimum interval of 1-2 sec. To prevent "bangs" during the valve change, two extra burners, in addition to the usual burn-out burners, are installed at the changing valves: one in the common duct before the branch-off to the boiler and the other in the duct in front of the boiler.

During the operation of the boilers no violent "bangs" occurred; this was due to a relatively high temperature in the ducts (usually not below 450-500°C), a thorough check on the tightness of the brickwork of the ducts, and the reliable operation of the burn-out burners. Usually light "bangs" occur in the flue mainly during the initial period of furnace operation after an overhaul, when the ducts are relatively cold.

The installation of the waste-heat boilers behind the open-hearth furnaces, has in addition to steam generation by utilization of the heat of the flue gases, resulted in a considerable increase in the draft. Deficiencies in draft are apparent in the furnaces without waste-heat boilers. The availability of an adequate draft reserve made possible a redistribution of the combustion products between the gas and the air regenerators by means of the distribution valve such as to ensure a high temperature of the air as well as of the gas checker (within the limits of 1220-1280°C). In addition, a good control of the predetermined pressure in the furnace itself by means of the guiding attachment of the gas-flue fan was attained.

The maximum vacuum which can be attained by the D-20 flue-gas fan is 100 mm of water. In actual fact, a vacuum of not more than 70-75 mm of water is maintained in the gas duct and, as has been already pointed out, at that vacuum a high temperature of gas checkers is attained. In order to employ a higher vacuum it is necessary to reduce the cross section of the gas apertures in the furnace ports as well as to improve the strength of the vertical gas channels, where an extensive erosion is observed on the furnaces where waste-heat boilers are installed.

At the maximum thermal load of the furnace during the charging period, the aerodynamic conditions, shown in Fig. 3, which are characterized by a high vacuum in the gas stream, are maintained.

The following conclusions can be made on the basis of practical experience in the operation of open-hearth furnaces with waste-heat boilers:

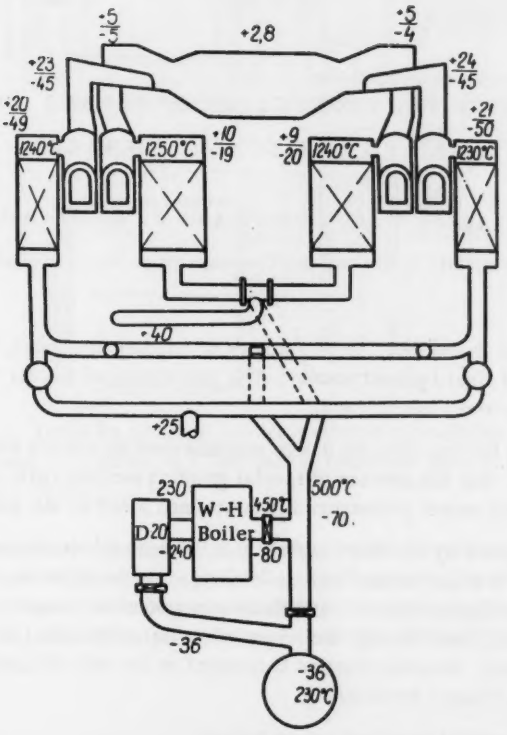


Fig. 3. Aerodynamic conditions of the open-hearth furnace during operation with the waste-heat boiler (numerator – pressure, mm of water, when gas is supplied; denominator – vacuum, mm of water, when flue gases are taken off).

1. The flue-gas fans should have adequate reserve capacity so as to ensure not only the utilization of the physical heat of the flue gases but also a high efficiency of the open-hearth furnaces. When the flue-gas fan and the waste-heat boiler are to be used, a possible future increase in the thermal loads of the furnace should be taken into account.

2. The strength of the separate elements of the open-hearth furnace should be sufficiently high to eliminate any limitations in making use of the draft provided by the flue-gas fan.

3. Waste-heat boilers should be constructed individually and not in a block because the whole block of boilers has to be shut down if there is any breakdown in the circulation system.

MECHANIZATION OF THE PRODUCTION OF POWDER MATERIALS IN STEELMAKING IN ELECTRIC FURNACES

A. I. Sapko, V. P. Dobrov and V. D. Kucherov

The "Dneprospetsstal" Works and the Dnepropetrovsk Metallurgical Institute

In making and casting high-grade steel, large amounts of ferrosilicon, coke, lunkerite mixture, and other materials are used in the form of finely ground powder. The preparation of powder materials at all the works of high-quality steel is not adequately mechanized.

This is, first of all, due to the fact that the design organizations do not pay adequate attention to this particular process and, second, that the absence of special grinding sections (with mechanized charging, grinding, and screening operations) causes production difficulties and a fall in the quality of the metal.

Powder materials are prepared by the following method. Lumps of ferrosilicon are charged by hand into a special box, taken by a crane to a jaw crusher and again charged by hand into the crusher. Ferrosilicon is then manually transferred to the crusher-roll mill and there it is ground to 1 mm – 5 mm fractions. The small-size fraction of ferrosilicon which passes through the screen of the roll mill into a receiving bunker is charged by hand to nonmechanized screens. Oversize fraction is returned to the roll mill, and the fine-ground fraction in the form of powder is used in electric steelmaking.

The disadvantages of the method described are as follows:

1. If in one shift, 45% and 75% ferrosilicon and coke or charcoal have to be prepared, the crusher rolls must be thoroughly cleaned after the grinding of each of these materials. Cleaning of the cup of the crushers takes a considerable time, thus greatly lowering the output, and, moreover, there is a considerable loss of material.

2. A large number of workers are engaged in the preparation of powder materials (3-4 men in each shift); working conditions are difficult and harmful because of an extensive dust evolution at the roll mill (it is difficult to cover the rolls tightly).

3. The rolls break down frequently, as they are not designed for grinding hard materials.

4. Mechanization of the separate operations of the process of powder preparation is lacking.

The production of the lunkerite mixture used for the top end of the ingots during steel pouring is not mechanized either, and it constitutes a labor-consuming and harmful process. Powdery components are screened and mixed manually.

At the "Dneprospetsstal" Works a number of valuable measures which provide for the mechanization of labor-consuming operations in the production of powder materials and an improvement of working conditions and the quality of product have been proposed and adopted.

For fine grinding of ferrosilicon, a special drum (Fig. 1), consisting of two end flanges joined to each other along the perimeter by square bars, was constructed. The diagonals of the squares are tightly joined to each other and lightly electrowelded. The driving shaft of the drum is mounted on roller bearings, and on one side is coupled to a two-stage reduction gear and the electric motor. The maximum speed of the drum should not exceed 35 rpm, because with an increase in speed its efficiency falls. Materials charged should not exceed 60% of the internal volume of the drum. The drum is closed from above with a tight jacket.

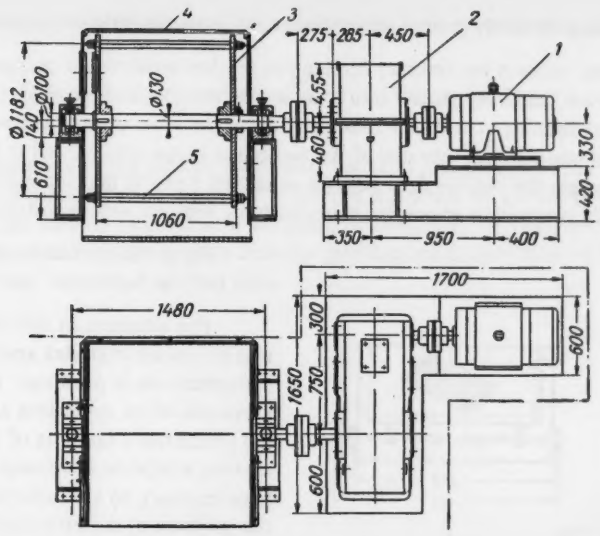


Fig. 1. Drum for grinding powder materials (ferrosilicon and coke): 1) Motor, N = 20 kw, n = 720 rpm; 2) reduction gear; 3) drum; 4) jacket; 5) rod.

When the drum rotates, the charged material is crushed by the impact and crashing together of particles and by their impact against the edges of the square rods. In order to increase the output of the drum and to extend the service life of the square bars, the components must be made of manganese steel. Worn out bars can be replaced while shaft and side flanges remain. The output of the drum is approximately 0,5 ton/hr.

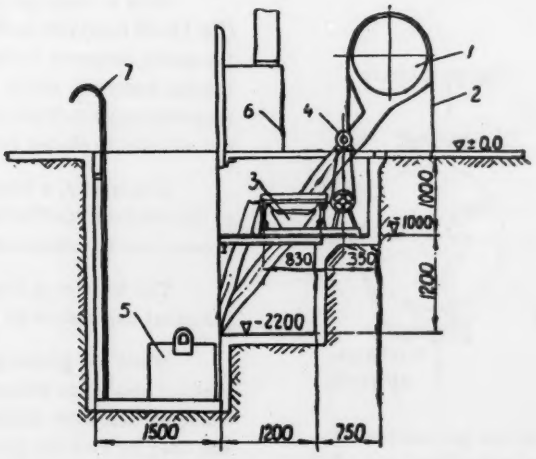


Fig. 2. Diagram of the equipment for the mechanized production of powder materials: 1) Drum; 2) drum jackets; 3) eccentric screen; 4) screen drive; 5) box for powder materials; 6) bunker; 7) ladder.

The production process of finely ground ferrosilicon consists of the following operations (Fig. 2).

Lumps of ferrosilicon, without preliminary crushing in the jaw crusher, are charged through the side door into the drum, where they are gradually ground into powder. As the powder is formed, it is screened into a special bunker where a mechanical eccentric screen (Fig. 3) for the separation of a given fraction of the powder is installed. The prepared powder falls into one of the two boxes in the bunker, and is then transferred into a special bin for powder storage; the residue falls into the other box * and is then returned to the drum. Separate drums are employed for the production of powder material from 75% and 45% ferrosilicon.

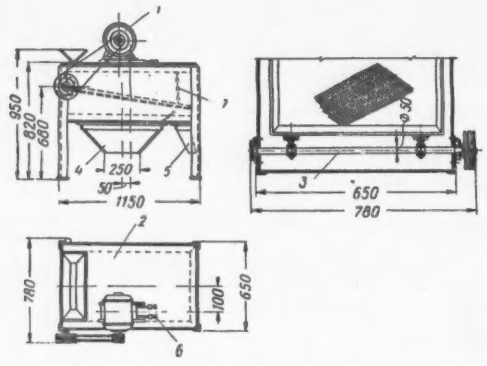


Fig. 3. Eccentric screen for the separation of powder materials: 1) Motor, N = 2.8 kw, n = 1440 rpm; 2) cover; 3) crankshaft; 4 and 5) runoff; 6) movable slides; 7) suspension.

For grinding coke or charcoal, similar drums with balls or ball mills can be used.

The adoption of this method for the preparation of powder material and the use of the above equipment made possible: 1) the complete mechanization of all operations and the elimination of the preliminary crushing of the ferrosilicon, thus making available additional space and equipment (jaw crusher); b) an improvement in the quality of the product; c) the elimination of dust, thus markedly improving working conditions and increasing the output of acceptable product; d) an increase in operating efficiency; e) the complete elimination of breaks in the supplies of powder materials for the electric furnaces.

A special mixing equipment was constructed for the preparation of lunkerite mixture (Fig. 4).

Constituent components of lunkerite, screened on the mechanical screen, are charged in determined weight proportions into the mixing machine. The charging aperture is tightly covered with a felt seal, and an electric motor, which drives the body of the mixing machine, is switched on. There is a closed aperture on the opposite side of the charge aperture.

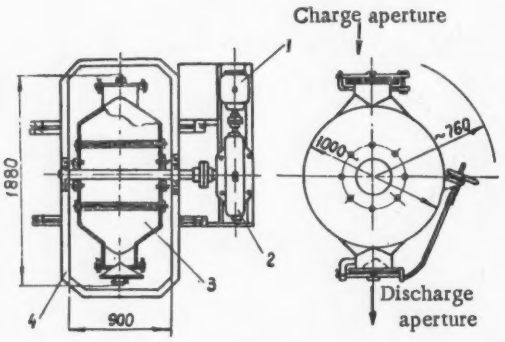


Fig. 4. Mixing equpiment for the preparation of lunkerite mixture: 1) Motor, N = 4.5 kw, n = 1000 rpm; 2) reduction gear; 3) drum; 4) frame.

After a thorough mixing of the components (for 15-20 min) the lower aperture is opened and the ready lunkerite mixture is discharged into a special container which is delivered on bogies by a narrow-gage railroad to the casting bay, where the mixture is placed into a special bunker.

In this way, a labor-consuming and, so far as the working conditions are concerned, harmful process can be completely mechanized.

The following conclusions can be drawn from practical experience at the "Dneprospetsstal" Works.

When the grinding sections of electric steelmaking plants are planned, the roll grinder as a size-reducing unit must definitely be avoided because it can only be used for grinding relatively soft materials.

Neither is the use of rolls for grinding coke, charcoal, and other materials desirable because of the difficulty in the elimination of dust carry-put during grinding. For grinding these materials, drums, which are used for grinding ferrosilicon and are simple in design and easy to make, or ball mills, can be recommended. The adoption of this equipment in conjunction with mechanical screens will make possible a full mechanization of the process of powder material

*In a normal operation of the drum the residue constitutes not more than 5%.

production and ensure normal working conditions for operating personnel, provided that the grinding machinery is enclosed.

Mechanical equipment (Fig. 4) can be recommended for the mechanization of labor-consuming processes in lunkerite mixture preparation.

When a complex automation of the section for powder material preparation is planned, the section should be made as a separate unit or plant for the production of powder materials for all the electric steel-making plants of the works. In this case, the method of automatic weighing of constituent components of lunkerite and special feeders for charging the materials from the bunkers into the grinding machinery have to be developed.

ROLLED AND TUBULAR PRODUCT INDUSTRY

IMPROVING THE ROLL DESIGN OF SECTION MILLS

Head of the structural-steel mill, I. F. Revenko

Roll designer of the structural-steel mill, I. M. Konovalov

Stalino Metallurgical Works

In order to increase output, reduce manual labor of rolling mill operators, improve the quality of rolled product, and distribute loads more uniformly over the working stands, the roll design for several steel sections at our works was revised.

The 400 mill is arranged in two lines; the roughing stand has rolls of 550 mm diameter, the finishing line consists of three stands with rolls of 400 mm diameter. The mill produces spring strip from 55S2 and 60S2 steels. In 1957, according to the new GOST standards, the specifications with regard to the dimensions of the section became more stringent and the product obtained from the old arrangement of roll passes became unsatisfactory.

The previous arrangement of roll passes for rolling 102 × 10 mm strip is shown in Fig. 1a. In the first stand free side spread was allowed in the first and second passes, in the second stand three passes (third, fourth and fifth) were of the box type, and in the third finishing stand two passes (sixth and seventh) allowed for a free side spread.

In the new arrangement of roll passes (Fig. 1b) a rectangular billet, 107 mm × 55 mm, is obtained from the roughing stand. The first stand of the finishing line has two passes — an edge and a box pass. In the second stand all three strip passes (third, fourth and fifth) are of the box type. In the third finishing stand the sixth pass is of the box type and only the seventh pass has a free lateral spread but a very small reduction.

The number of passes in both stands remained as before and only the design of the passes was modified. The first edging pass serves for straightening the piece and removing any nonuniformity in width which appears on thick billets after passes which allow for free lateral spread. The side-restricted passes with rounded-off edges ensure an easy entering of billets into the pass, and a rolled piece of a uniform width is obtained. Attempts were made to place the edging pass before the finishing pass, but entering the thin strip into the edging pass was very difficult. Hence the output of the mill was reduced and the amount of rejects increased, and therefore, it was found necessary to dispense with the edging pass.

During operation with the new scheme, the output has not fallen and the accuracy in the dimensions of the section has been enhanced; now all spring strips are rolled in the 400 mill by the new method.

The 350 mill consists of a roughing stand with rolls of 500 mm diameter and a finishing train comprising four stands. In the production of No. 24 hexagonal section on this mill, the elongation passes of the finishing line were modified (Fig. 2a). The last three passes (finishing, prefinishing and square) remained unchanged. Two rhombic passes were designed (Fig. 2b) instead of four elongation passes (first, second, third and fourth).

Now, owing to the elimination of two passes, the rolling of the strip is completed at a higher temperature and hence the durability of housings and rolls has increased; entering the piece into the rolls is made easier, and the amount of rejects is reduced. According to the old arrangement the first, second and third passes were on the first stand, the fourth and fifth — on the second, the sixth pass — on the third stand and the seventh, finishing pass, on the fourth stand.

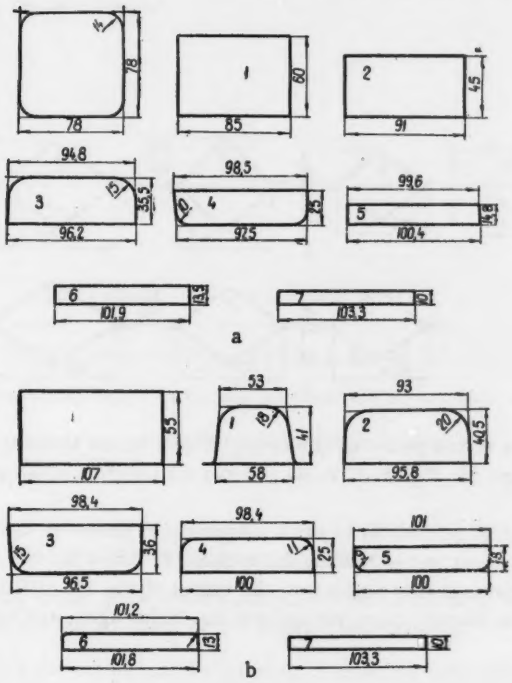


Fig. 1. Arrangement of roll passes for producing spring strip, 102 mm × 10 mm: a) Old design; b) new design (the dimensions of the first pass are given according to the templet); the figures 1, 2, etc., denote the numbers of the passes.

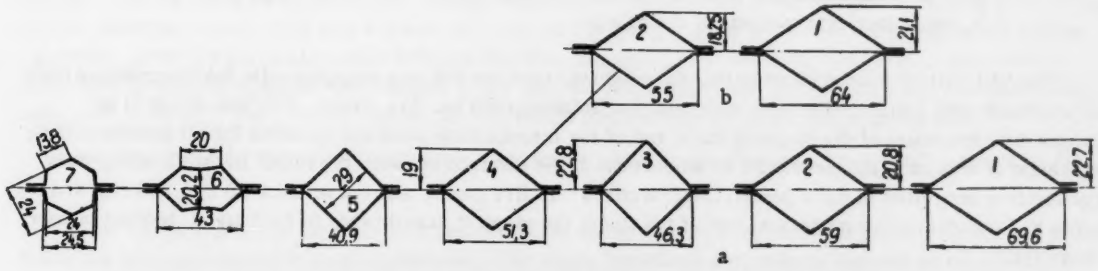


Fig. 2. Arrangement of roll passes for producing No. 24 hexagonal section: a) Old design; b) new design; the figures 1,2, etc., denote the numbers of the passes.

According to the new arrangement, the first and the second passes are on the first stand, and the last three passes are placed one on each of the subsequent stands. With the new arrangement, it is much easier to carry out rolling with overlapping than with the old pass arrangement. Only on the first stand do the shorter billets go through twice; in the remaining stands there is only one pass in each. The duration of rolling in the finishing train and in the roughing trains is now the same. For better gripping, steel rolls are employed on the first stand.

In the 350 mill, the pass arrangement for producing 22 mm square section has been modified (Fig. 3). The old pass arrangement was: rhombus – square (Fig. 3a). In the new pass design (Fig. 3b) the rolling is carried out according to the scheme: rhombus – rhombus, and hence the section can be produced in the finishing train in five passes instead of seven, i.e., two on the first stand and one each on the second, third and fourth stands. As a result, the same advantages have been obtained as in the rolling of No. 24 hexagonal section.

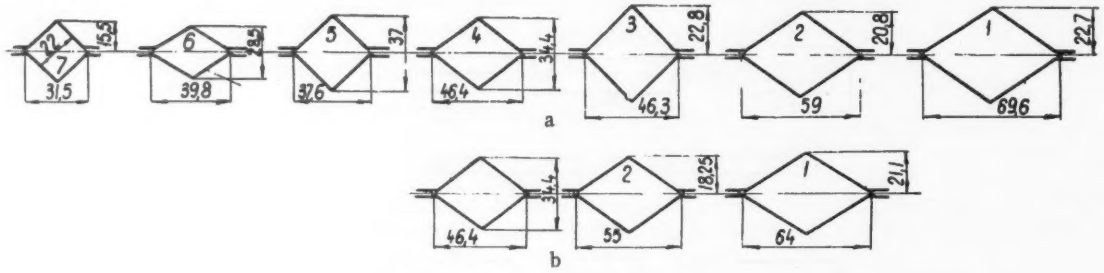


Fig. 3. Arrangement of roll passes for producing 22 mm square section: a) Old design; b) new design; the figures 1, 2, etc., denote the numbers of the passes.

The same type of changes were carried out in the arrangement of passes for the production of round sections of 26 mm and 27 mm diameter and of rectangular sections 21 mm x 26 mm, 30 mm x 16 mm, 30 mm x 18 mm, and 35 mm x 18 mm. In this connection, the output of the 350 mill increased considerably; by 15-18% in the production of the 22 mm square section and No. 24 hexagon, and by 10-15% in the production of 26 mm – 27 mm rounds.

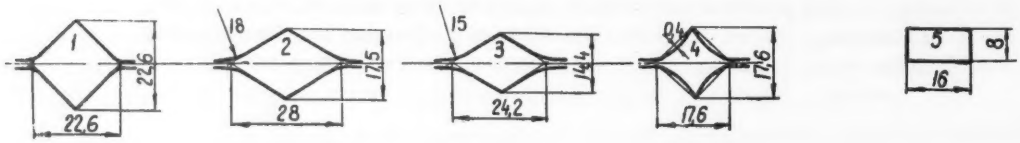


Fig. 4. Arrangement of passes for producing bar 8 mm x 16 mm; the figures 1, 2, etc., denote the numbers of the passes.

The 250 mill consists of three trains: the roughing stand has 500 mm diameter rolls, the intermediate train has two stands with 350 mm diameter rolls, and the finishing train has five stands. The pass design is so arranged that the passes of the roughing stand and of the intermediate train are the same for all sections rolled; the change of section is allowed for by an adjustment of the distance between the rolls. In the finishing train large sections are rolled in three passes; small sections – in five passes and the sections 20 mm x 4 mm and 20 mm x 5 mm – in seven passes (on two of the stands the piece is passed twice in each stand; looping of bars is employed).

The plant has mastered the production of 8 mm x 16 mm bar from 55S2 steel.

On rolling narrow pieces (when the width : thickness ratio is not more than 2) in plain (nongrooved) rolls, a large side spread is obtained and therefore an additional edging pass is necessary. On leaving this pass, however, the strip is not uniformly thick across its width and hence the strip is susceptible to twisting in the finishing pass.

All the disadvantages mentioned above are absent in rolling narrow strips from a square section with convex sides, as has been confirmed by practical experience in the production of 8 mm x 16 mm strip. The

first stand has a square pass; the second, a rhombus; the third, a rhombus; the fourth, a square with convex sides; and the fifth has plain rolls. This arrangement of passes for producing 8 mm x 16 mm strip was found very satisfactory.

An adjustable guide box, which facilitates entering the billet and prevents it from twisting, is employed in the rolling operation by the new method.

AUTOMATIC GRIPPING GUIDE BOX

N. V. Samotesov, Deputy Head of the OTK

L. R. Ratsevich, Inspection Foreman of the OTK at the sectional rolling mill

Stalino Metallurgical Works

Our works supplies steel spring strip (45 mm x 6 mm, 45 mm x 6.5 mm, and 45 mm x 7 mm) with parabolic edges, made of steel 50Kh, to the Gor'kii Automobile Works.

For a long time, owing to the guide box for the production of this strip being manually operated, a large amount of defective material – due to "fins" on the edges – was produced.

The manual tightening did not permit the operator to close the rolls simultaneously with the entering of the billet into the finishing pass; hence fins were produced on the edges of the strip over a length of 4-5 m on each piece.

The innovators of the works proposed an original design for an automatic, tightening guide box; its introduction resulted in a complete elimination of defects due to fin formation. A general diagram of the automatic pass box on the finishing stand of the 350 mill is shown in Fig. 1.

As the starting pulse for the operation of the box, the elastic deformation of the rolls when the rolled piece enters the finishing pass is utilized; the upper roll then presses through the textolite piece (1) on the rod (2). The rod actuates the automatic controller (3) which switches the electromagnetic coil (4) (P = 125 kg) into the electric circuit. The coil actuates the pull rod (5) and the gears (6) and so the passes in the box are tightened. After the piece has passed between the rolls, the spring (1) returns the rod (2) with the textolite piece into its original position; the contacts in the automatic controller are disconnected and the electromagnetic coil is cut off. The pull rod returns to the initial position and opens the passes in the box.

The apparatus for the current-initiating pulse for switching in the electromagnetic coil is shown in Fig. 2.

The textolite piece is mounted in a special holder which connects the textolite piece with the rod placed inside the tube with textolite plugs at the ends. The whole automatic apparatus is fastened to the housing by means of the tube and the bars. A hinge fork and a supporting bracket are welded to the upper part of the tube; a contact lever is attached to the hinge fork. The spring, placed between the contact lever and the supporting bracket, serves for disconnecting the contacts of the controller when the rolled piece leaves the rolls. The distance between the two contacts is adjusted by means of the stop bolt.

The diagram of the constant-distance automatic controller is shown in Fig. 2. If the distance between the rolls is changed (during mill adjustments), the controller frame is automatically displaced, a constant distance between the contacts being retained.

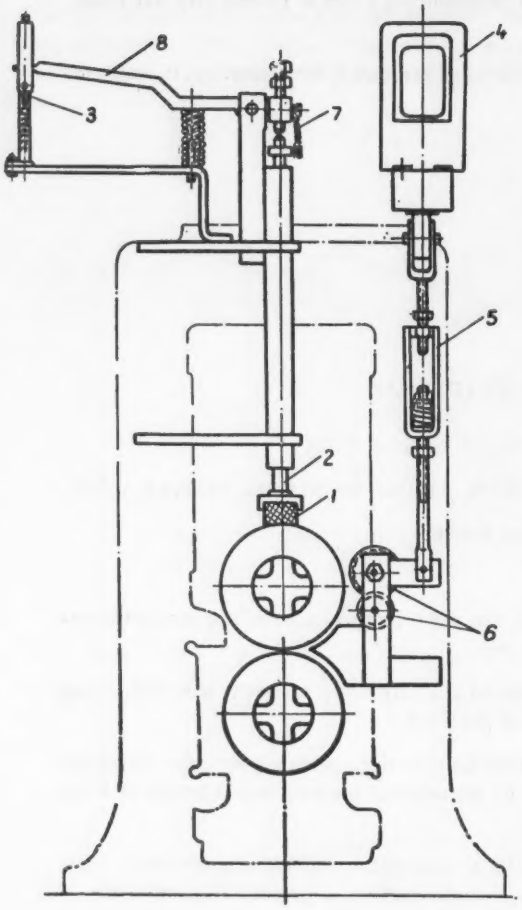


Fig. 1. Diagram of the automatic gripping box. 1) Textolite piece; 2) rod; 3) controller; 4) electromagnetic coil; 5) pull rod; 6) gears ($z_1 = 10$, $z_2 = 30$); 7) spring; 8) contact lever.

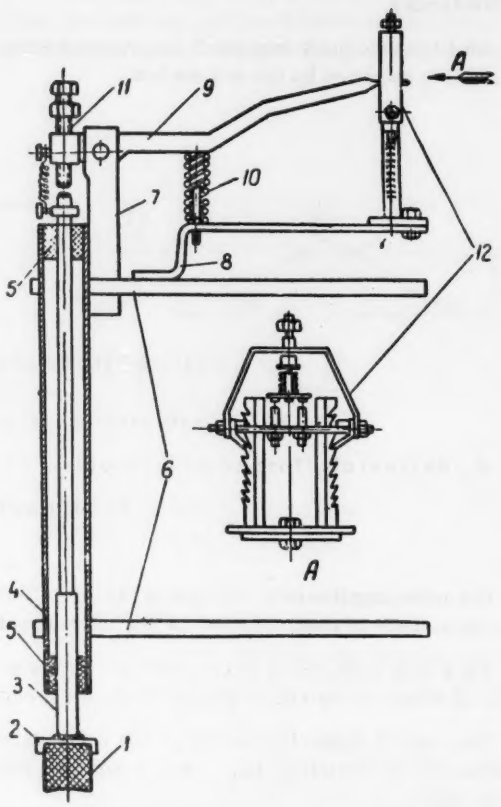


Fig. 2. Automatic apparatus for current-initiating pulse in the electromagnetic coil. 1) Textolite piece; 2) holder; 3) rod; 4) tube; 5) textolite plugs; 6) bars; 7) hinge fork; 8) supporting bracket; 9) contact lever; 10) spring; 11) stop bolt; 12) constant distance controller.

Figure 4 shows the pulling equipment which effects the tightening of the passes in the box when the rolled piece enters the rolls. In the upper part, there is a crotch for attaching the pull rod to the electromagnetic coil. The lower crotch of the pull rod is joined to the crossarm of the gear of the pass box. The two crotches are connected by a yoke which serves for adjusting the total length of the tension of the pull rod. A locking nut prevents a reverse motion of the yoke during the operation of the equipment, and controls the extent to which the passes in the box are opened. The spring (P = 90 kg) ensures a constant force of the gripping of the billet in the passes, regardless of the wear of the passes.

The operation of the electromagnetic oil in the automatic gripping box is shown in Fig. 3. The working voltage is 36 v when the contacts of the controller are closed, and thus a safe operation of the apparatus is ensured. The electromagnetic coil is supplied with 380 v current through a starter.

The automatic gripping box on the 350 mill has been working reliably for over two years. In addition to a considerable reduction in defective products, the introduction of the automatic box made the work of the operators at the finishing stand much easier.

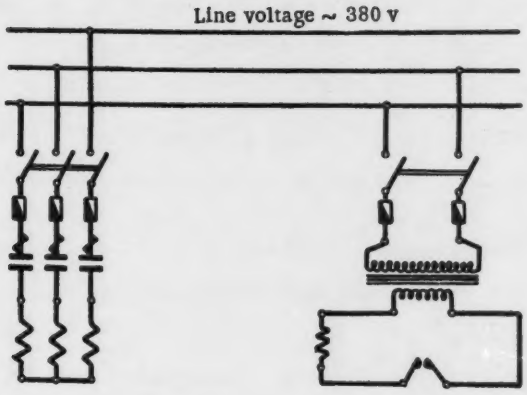


Fig. 3. Diagram of the electric circuit for electromagnet operation.

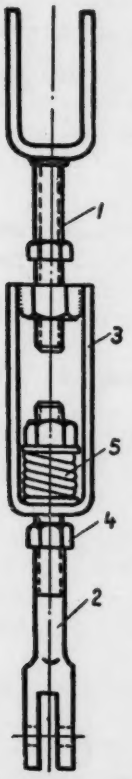


Fig. 4. Pull rod. 1) Upper crotch; 2) lower crotch; 3) yoke; 4) locking nut; 5) spring.

Such boxes may be successfully employed in the production of all sections which require the tightening of the passes when the piece enters the rolls; it is also possible to use these boxes at mills which are equipped with transfers and where it is essential to ensure a steady position of the piece between the rolls.

REMOVAL OF FURNACE SCALE FROM THE SURFACE OF ROLLED PLATE BY MEANS OF A STEAM AND GAS BLASTING METHOD

M. I. Bazhenov-Korchemnyi and L. I. Danilov

The Kuznetsk Metallurgical Combine

In plate-rolling production a common method for the removal of furnace scale is the use of small birch twigs (whisks) which are thrown onto the surface of the rolled piece just before it is entered between the rolls. This method, however, is labor consuming and does not ensure a complete removal of scale; the reverse side of the plate is not treated as it is not possible to throw twigs from below.

Another widely employed method is the hydraulic removal of scale; but even with water at 100 atm pressure this method is not sufficiently effective, particularly for alloy steel.

In the search for the best method of scale removal from rolled metal, attention was drawn to the following phenomenon. When plates were rolled with rolls which were indented in some places, the plates produced had spots which were always brighter and cleaner than the remaining surface of the plate. It was found that cooling water gets into indented places on the rolls and is trapped between the body of the roll and the hot metal (Fig. 1).

At the time of deformation (in the actual place of deformation) the water is instantly transformed into high-pressure steam, and when the rolled metal is leaving the rolls this steam erupts violently from the cavity and removes the scale, not only from the spot itself but also from the neighboring areas on the plate. On the basis of the analysis of this phenomenon, a special middle roll with cavities on its surface was made and mounted on the three-high roughing Lauth stand. A test rolling with the use of such a roll showed that all the scale is removed in the first few passes without the application of birch twigs.

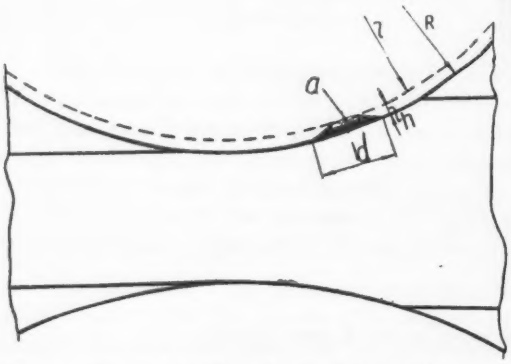


Fig. 1. Contact of indented roll with rolled piece: a) Accumulation of high-pressure steam and gas.

The blasts resulting from steam formation in the cavities are sufficiently powerful to remove the scale efficiently during the rolling of alloy steel. The splashes from hot scarfing and shallow scabs are also removed. In addition to its action on the scale, such a roll works up the outer layers of metal effectively; seams and even fissures up to 3 mm deep are rolled out without a trace.

The dimensions, shape, and layout of the cavities on the roll are determined by empirically established formulae (Figs. 1 and 2):

$$\frac{d}{R} = 0.093 - 0.113;$$

$h \leq \frac{d}{5}$ – for the middle roll of the three-high Lauth mill;

$h \leq \frac{d}{7}$ – for rolls of two-high mills, where R – roll radius, mm;
h – depth of cavities, mm;
d – diameter of cavities, mm;

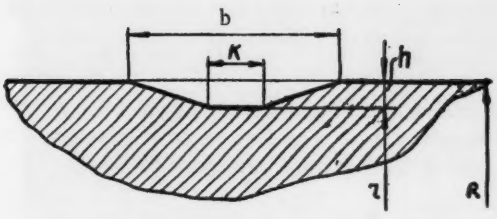


Fig. 2. Cavity on the roll.

a = (2.0 – 2.4) d – distance between the centers of the cavities along the axis of the roll,
b = (1.3 – 1.5) d – length of the cavity along the axis of the roll;
c = 1.5 d – distance between the centers of the cavities along the perimeter of the roll;
k = (0.3 – 0.5) d – length of the stroke of the cutter during the cutting of the cavities (length of the cavity).

For a more effective removal of the scale during the rolling process, a thick suspension, instead of water, is employed; the suspension is prepared in water with coal dust, fine sawdust, waste from the paper industry, waste from peat charcoal production, and other readily inflammable materials which yield a large amount of gases.

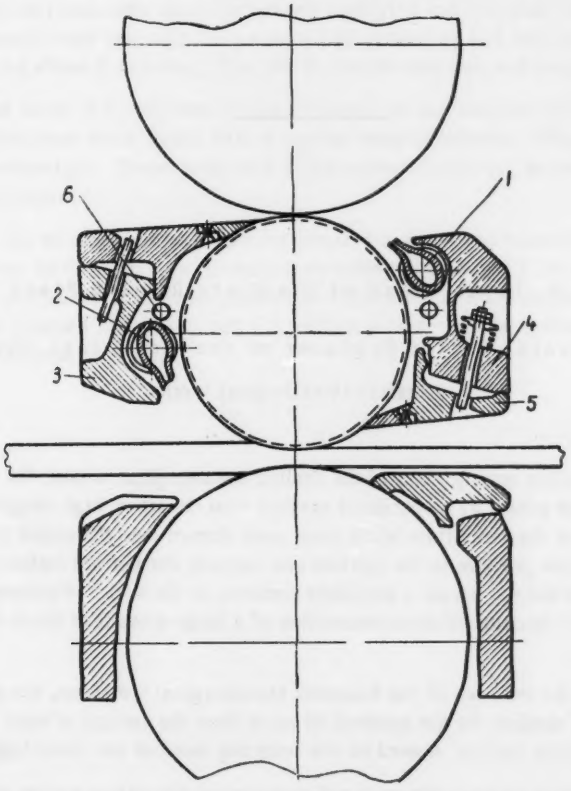


Fig. 3. Arrangement of receivers on three-high Lauth mills. 1) Receiver for spraying the emulsion on the lower side of the rolled piece; 2) receiver for spraying emulsion on the upper side of the rolled piece; 3) front guide block; 4) guide block; 5) suspension guide; 6) spray for roll cooling.

The prepared suspension is charged into a special container placed next to the plate rolling mill. The mixture is agitated with compressed air or mechanical stirrers to keep the solid particles suspended.

A piston pump is placed under the container for pumping the suspension from the container through flexible hoses to the spraying receivers. The pump is driven by compressed air. The operation of the air cylinder of the pump is controlled by means of a four-way valve and can be made automatic.

The spraying receivers on the Lauth mill are mounted on both sides of the middle roll between the roll and the guide blocks (Fig. 3), and serve for spraying the rolled piece from above and below alternately. The method of mounting the spraying receivers on two-high and four-high mills has only minor constructional modifications. Each receiver has its working and air cylinders, so that one or other cylinder is switched on when required.

For a better flow of the suspension through the hoses, the cylinders and the container are placed at a higher level than the spraying receivers. The receivers are tubes with slits or holes for suspension spraying. They are made in a tapering form for a more uniform distribution of the suspension throughout the whole length of the tube.

With the gas-producing suspension, a higher pressure is obtained in each cavity of the roll, owing to the instantaneous combustion of the ingredients; hence a more violent outburst occurs at the moment when the rolled piece leaves the rolls, and the scale is removed more effectively. Therefore, the shape of the cavities can be considerably simplified.

A long series of tests has proved conclusively the effectiveness of the application of rolls with surface cavities for the removal of furnace scale and other defects from the surface of metal in the roughing mills.

M. A. Lapis, Head of the Plate Rolling Plant

E. F. Koshevaia, Senior Engineer of the Technical Department

Stalino Metallurgical Works

Until recently, at the plate rolling plant of the Stalino Metallurgical Works, the furnace scale was removed from the surface of the plates by a combined method – on the three-high roughing stand the scale was removed hydraulically, and at the same time birch twigs were thrown onto the rolled pieces before it entered the rolls. Owing to a low water pressure in the nozzles and because the bottom surface could not be treated with birch twigs, this method did not ensure a complete removal of the scale. Furthermore, this method is disadvantageous economically because of the consumption of a large amount of birch twigs and expensive purified water.

Since 1957, following the practice of the Kuznetsk Metallurgical Combine, the plate rolling plant is using a new steam-blasting method for the removal of scale from the surface of steel plate. A special middle roll which has cavities cut on its surface is used on the roughing stand of the three-high mill (Fig. 1).

This method has proved to be very effective and economical for rolling almost all grades of steel, as it ensures a complete removal of the scale from both sides of the rolled piece in few passes.

The cavities on the rolls are made with a pointed drill on the "Taush"* boring machine with the stays on roller bearing. First the roll is marked; during the machining, the roll is turned by a crane. The cavities are oval in shape and are placed in a checkered pattern over the whole area of the roll (Fig. 2). The distance

*Transliteration of Russian – Publisher.

between the cavities is not more than 92 mm and their initial depth not more than 6.5-7 mm. If the distance between the cavities is greater and their depth smaller the effectiveness of such rolls is reduced.

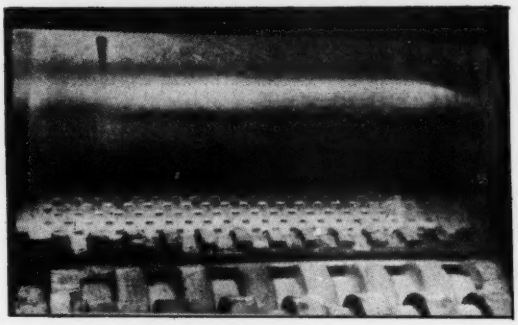


Fig. 1. Middle roll with cavities.

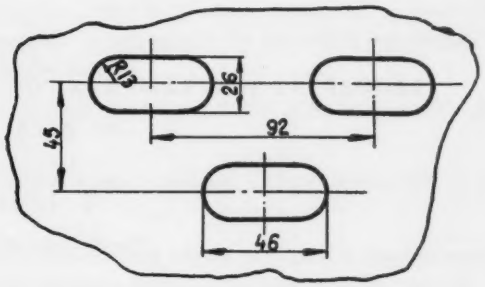


Fig. 2. The layout of cavities on the surface of the roll.

In 1957, drilled rolls made of steel or chilled cast iron as well as magnesium cast iron and molybdenum cast iron were tested.

Tests showed that cast iron rolls ensure satisfactory gripping and are more durable than steel rolls. In particular, the molybdenum cast iron rolls have a very high durability and last for three campaigns, the depth of the cavities then being about 3.5-4 mm. The life of chilled cast iron and magnesium rolls is two campaigns.

On steel rolls, the walls of the cavities become pressed out and rounded off in the course of rolling, and the surface of the roll becomes more coarse with a marked erosion network. After being machined, the steel rolls also last for two campaigns. Towards the end of the second campaign, however, the effectiveness of scale removal is considerably reduced.

The adoption of the middle rolls with cavities resulted in a marked improvement in the quality of the plate surface, a reduction in the amount of trimming on scale removal, and a cut to the minimum in the use of twigs during rolling processes. It was also possible to dispense with the erection of a water-storage station – which had already been planned and was to cost 1.2 million rubles – for the increase of water pressure to 100 atm for the hydraulic removal of scale.

RECORDING INSTRUMENTS FOR THE TECHNOLOGICAL PROCESSES OF STEEL ROLLING

E. I. Sametskii

The Stalino Metallurgical Works

Automatic recording of the course of technological processes makes it possible to analyze these processes, to determine the causes and the extent of stoppages, and hence to plan steps for improving operating efficiency, for reducing defective products, for improving the quality of products, etc. With these objectives in mind, the KIP and Automation Plant of the Stalino Metallurgical Works produced, and installed on various units, instruments for recording technological processes.

Recorder of the operation of the three-high stand. In the plate rolling plant an instrument which records the operation of the three-high reversible rolling mill has already been used regularly for more than two years. Owing to this instrument, the following information can be evaluated from the chart: the number of passes and the absolute value of draft, in mm, in each pass; the time taken for each pass and for the total rolling process of an ingot or a slab; the number of times the piece was turned over and the time taken for each turning, and the time of stoppages. A diagram of the equipment is shown in Fig. 1.

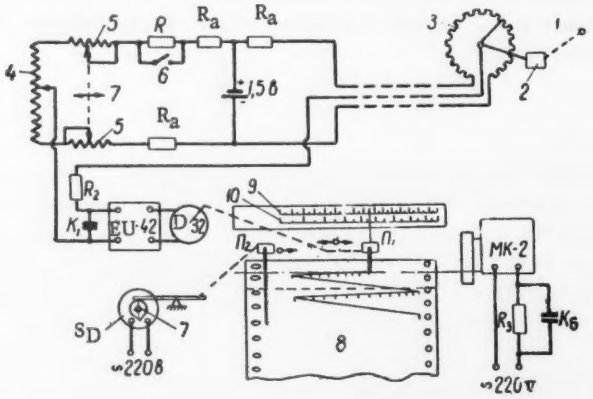


Fig. 1. Diagram of the equipment for recording the operation of the three-high stand: 1) Shaft of the draft indicator; 2) draft indicator; 3) rheostat data transmitter; 4) secondary instrument; 5) double rheostat; 6) switch; 7) zero adjuster; 8) chart sheet; 9) ingot scale; 10) slab scale.

The shaft of the draft indicator is rigidly connected, through a reducing gear equipped with a spring for slot selection, to the rheostat data transmitter. Direct current is used for the rheostat (1.5 v); with the appropriate

modification of the circuit, low-voltage alternating current can also be used. The slide wire of the data transmitter is connected to the slide wire of the secondary instrument by a three-wire line. A modified potentiometer, type EPP-09, is employed as the recording instrument. Adjusting resistance R_a is required for the calibration of the follow-up system.

The resistance R_1 and the switch serve for changing over from one scale to another. The resistance R_2 and the capacitor K_1 protect the EU-42 amplifier from stray pickup. The D-32 motor, controlled by the EU-42 amplifier, moves the indicator along the scale of the instrument; the indicator has a pen which reproduces, to a corresponding scale, the movements of the upper roll of the stand.

The double rheostat serves for zero adjustment on the recorder scale. The MK-2 motor moves the chart at a speed of 0.8 m/hr.

The synchronous motor, SD, drives the time recorder, which makes 1 min and 10 mins time marks on the left-hand side of the chart.

On the basis of the study of a series of charts, the Work Organization Department gave a detailed analysis of the three-high stand operation and worked out appropriate measures aimed at a reduction of idle periods. During a long period of use the equipment proved to be reliable and easy to operate.

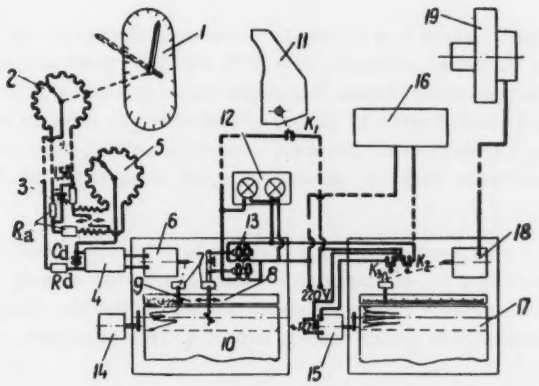


Fig. 2. Diagram of equipment for recording the cogging mill operation: 1) Mill draft indicator; 2) resistance wire of data transmitter; 3) zero adjuster; 4) electronic amplifier; 5) resistance wire of the instrument; 6) equalizing motor; 7) pens; 8) ingot delivery scale; 9) normal temperature scale; 10) electronic potentiometer for draft measurement; 11) receiver; 12) lamp register; 13) double electromagnets; 14 and 15) synchronous motor; 16) lamp register; 17) electronic potentiometer for temperature measurement; 18) equalizing motor; 19) sighting head FEP.

The recording of the cogging stand operation. For more than a year an instrument which constitutes a combination of the rolling mill operation recorder and the FEP-3 photoelectric pyrometer has been in operation in the blooming mill plant.

In addition to the above-mentioned parameters, the instrument also records the time from the moment of ingot delivery to the mill to the first pass, the number of ingots rolled, and the deviation of actual temperature of the ingot rolled from the design temperature.

The diagram of the equipment is shown in Fig. 2. The follow-up system of the equipment is similar to the one described above.

Above the recording device a double electromagnet of the recording pen is mounted; it is operated by the primary data transmitters, which are installed at the ingot receiver of the mill and at the FEP-3 photoelectric potentiometer (contact of limiting temperature). The contacts of these data transmitters also control light signals (colored bulbs for the control engineer of the plant) and on the lamp register "Rolling Permitted" for the operator of the stand. The FEP-3 sighting head is placed near the stand on the side of the shears and is directed towards the 2nd and 3rd pass, where the ingot is clean from scale after the first turning. If the temperature of the ingot is not below the permissible one, the pen, operated by the upper electromagnet, makes a few marks on the left-hand side of the chart.

The lower electromagnet records, by strokes to the right, the entry of the ingot onto the table rollers.

In the course of the operation of the equipment it was found that the recording of mill operation and temperatures on different charts was inconvenient. Hence, a new recording equipment which records mill operation and the accurate temperature of the ingot simultaneously on one chart was produced and tested.

ORGANIZATION OF PRODUCTION QUALITY CONTROL

AUTOMATION AND MECHANIZATION OF PRODUCTION CONTROL

N. V. Samotesov

The Stalino Metallurgical Works

In the article "Organization of production quality control" by N. P. Inozemtsev, Ia. I. Sokol, I. F. Rysev, D. A. Tarasenko, and S. I. Zamiatin, published in the "Metallurgist" No. 9, 1957, the problem of OTK staff reduction and of the increased responsibility of plant personnel was raised. We publish here a reply to this article.

The simplification of the organization of technical control at a works cannot be achieved by the reduction of OTK staff alone. Simultaneously with the OTK staff reduction, technical and organizational measures which would ensure high quality production in the absence of special controlling staff should be carried out. The greatest attention in the streamlining of technical control at works should be paid to the improvement of means and methods of quality control of manufactured products. Several metallurgical works use new control methods in steelmaking, rolling, and thermal plants extensively, but their experiences are not passed on to other establishments.

The employees of the "Serp i Molot" Works rightly stress the necessity for a revision of OTK functions in operational control, but they give no concrete proposals with regard to the organization of the control of separate processes in metallurgical production. Neither have the authors answered the second very important question – how to reorganize the production quality control at steel rolling plants, where actually the main body of the OTK personnel is engaged.

Many works have long since abolished the OTK control personnel in the blast-furnace plants and in inter-plant product inspection, the functions being entrusted to the personnel of the respective plants and departments. Practical experience at the Stalino Metallurgical Works showed that the reduction of the OTK personnel engaged on technological control in the blast furnace plant and in the inter-plant product inspection section caused no operational complications. The quality of pig iron did not fall, and the responsibility of the personnel of the plants and the supply department for the quality of raw and repair materials, scrap and fuel has increased.

At the steelmaking and rolling plants, however, the OTK staff still remains quite large. At the steelmaking plants, the OTK usually carries out the control of the whole technology of steelmaking and pouring including the post-operational control of the quality of the preparation of the ladle, runner, or molds for the next heat.

When the production quality control in steelmaking plants is reorganized, it should be borne in mind that these plants incur the main losses of the works due to defective products. Therefore, when reducing control (inspection) points in the steelmaking plant, one should take into account the specific aspects of the operation of each plant, the grades of steel produced and the standard specifications for their quality. The same systems of technological control should not be introduced in steelmaking plants producing ordinary steel and in plants producing high quality, alloy, and special steels.

The technical control in the steelmaking plant should be reorganized in stages. First of all the extent of the control by the OTK of steelmaking and pouring processes may be substantially reduced. In this way, the personnel of the steelmaking plant will be assisted in searching for new methods of controlling the

technology of making and pouring steel and in finding further ways for reducing the OTK control personnel engaged on the control of making and pouring high quality, alloy, and special steels.

A successful introduction of the new organization of production quality control in the steelmaking plants will depend to a large extent on how far the plant head, the section head, and the foreman will be responsible for product defects discovered by the consumer. At present, the works director and the head of the OTK are principally responsible for the defects found by the consumer and this affects, to a certain extent, the organization of technical control on those plants.

At the Stalino Metallurgical Works, 75% of all OTK personnel is employed in the steel rolling plants, including 55% of the controllers on the inspection of final product. These figures are also typical of other metallurgical works which produce many grades of alloyed and high-quality steels as well as complicated and difficult rolled sections. Hence, the new methods of production quality control should be introduced first of all in steel-rolling plants, since otherwise a substantial streamlining of the technical control will hardly be possible.

The automation and mechanization of the methods of production quality control have been successfully introduced recently at several works. In steel rolling plants, instruments for recording the amount of draft and the number of passes, and photopyrometers for measuring the temperature of rolled metal, are extensively used; the heating processes of the metal before rolling are automated, and various improvements in construction and equipment of mills are carried out. All this enables the rolling plant workers themselves to supervise the technology of heating and rolling of metal in all shifts, without a special OTK personnel. For instance, the functions of the OTK in the heating sections of the rolling mills at the Stalino Works are limited, in the main, to the prevention of intermixing of metal from different heats during the rolling process. In the finishing sections of the rolling mills, however, the new methods of production quality control are, so far, being introduced at an extremely slow pace.

The operation of the mechanized benches of the 250 mill, which serves for rolling round, square hexagonal and rectangular sections, can be given as an example of the mechanization of the quality control of finished products at the Stalino Works. Prior to the mechanization, the finished rolled pieces (Fig. a) were passed from the cooler to the press and, after being cut into the required length, were thrown into the collecting containers, from which the material was transferred in packs of 4-5 tons to the scales. Weighed material was placed on a special platform in the finishing section and was then delivered, in accordance with an established schedule, to the sorting benches for inspection and grading. Graded material was again weighed and dispatched to the finished product storage.

With the inspection and grading organized in such a way, a great amount of unfinished product accumulated in the finishing section as the grading was lagging behind the hot rolling operations. Space for grading benches and a large number of inspectors and workers in the plant were required.

To simplify the technology of grading rolled products, mechanized benches (Fig. b), 17 m long and 7.65 m wide, were installed on the floor where unfinished products were previously stored. The benches are 0.7 m high at the end where the metal is received and 1.0 m high at the other end, near the delivery containers.

The benches have six tracks, with moving sprocket chains, which divide the benches into five sections: Section I – 1.5 m wide; section II – 1.2 m; III, IV and V – 1.65 m, the different widths being due to the various lengths of the rolled bars. The longest bar which can be placed on the bench is 9 m, the shortest – 3 m. The sprocket chains are moved by a sprocket wheel driven by a 14-kw electric motor. The bars move at 5 m/min. The main structure of the benches is made of U-beams; total bench weight – 12.7 tons.

Now, after the rolled material is cut into the required length, the pusher throws the ready-cut bars onto the sprocket chains of the bench. The material is inspected and sorted during its progress on the bench. The bench is served by two controllers who check the surface of the bar and the dimensions of the cross section at both ends of the bar; one controller stays at the bench near the scales all the time, and the other stays on the opposite side or at the 3rd and 4th sections of the bench, depending on the length of the bar.

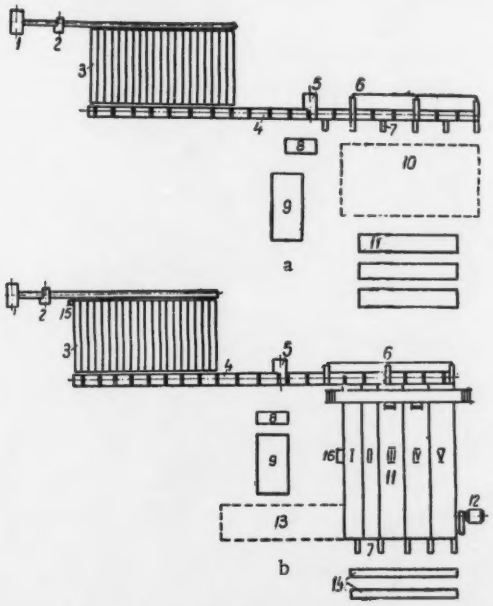
Rods which do not satisfy standard specifications are marked with chalk and pulled out about 200-300 mm towards the scales. At the end of the bench, before the material is thrown into the discharge containers, these rods are removed.

The material received is accumulated in the containers, then it is bound into packs of 4-5 tons, and after being weighed and marked it is dispatched to the finished product store. Permission for the use of this material is given by the OTK after the results of mechanical and technological tests are received from the Central Works Laboratory. To prevent the confusion of metal from different heats, the rolled pieces are spark tested directly on the bench.

Substandard rods, removed from the bench during the inspection, are accumulated on the floor of the finishing section. They are bound into packs and are marked as second grade (if they satisfy the specifications for the second grade) or are sent for additional treatment (cutting, straightening) and then they are finally accepted by the OTK.

If there are serious violations of the technological procedure of rolling so that it is impossible to separate rods which do not satisfy standard specifications, the OTK personnel do not inspect the material while it is moving, but direct it for additional grading, and stop the mill.

Since the installation of the mechanized bench, the violations of the technology of rolling have become markedly less frequent. Two factors contribute to this: firstly, the foremen of the mill are financially responsible for the quality of the metal delivered in their shift, and secondly, a systematic hot heading test and surface etching test have been introduced. Samples for hot heading and etching are taken every 10th-15th billet by means of cutters mounted in front of the cooler. Such a strict control of the quality of the finished product surface enables the foreman to remove any defects of the finished product due to the rolling operation and to prevent a large-scale accumulation of defective material on the mechanized bench in time.



Arrangements for production quality control and for grading rolled material at the 250 mill. a) Prior to the installation of mechanized benches; b) after the installation of mechanized benches; 1) the last stand of the mill; 2) flying shear; 3) cooler; 4) delivery roller tables; 5) press for metal cutting; 6) movable stops; 7) discharge containers; 8) control panel; 9) scales; 10) space for unfinished products; 11) mechanized bench; 12) electric motor; 13) place for the removal of substandard bars; 14) place for piling standard bars; 15) cutters for sample taking; 16) instrument for the metal spark test.

At present, the OTK inspects on the mechanized bench all normal and uniform-length sections of ordinary and high-quality steel rolled on the 250 mill. For the time being, the product made for export is inspected on the stationary sorting benches, as it has to be bound into packs of 100-500 kg and this would delay the removal of the finished product from the mechanized bench.

The mechanized bench allows for the cutting of finished pieces into two uniform lengths, up to 4 m, at the same time.

The introduction of the continuous method of inspection and grading of finished material at the 250 mill resulted in 12 OTK controllers and 9 mill workers being available for other work. Moreover, the responsibility of mill foremen for the quality of production was increased and the throughput capacity of the finishing section was raised.

A further improvement in the construction of the mechanized bench – a possible binding of the products into packs of any weight on a continuous basis adjusted to the course of the rolling process – will allow maximum streamlining of the organization of rolled product quality control and a further reduction in the OTK and plant personnel.

So far, unfortunately, it is impossible to introduce the same method of inspection at the 350 and 400 mills as there is no space available for the installation of mechanized benches.

It is seen from the experience of the Stalino Metallurgical Works and other works that a high quality of the product can be attained even with a very limited OTK control personnel if automation and mechanization are made use of in control operations. In this connection, scientific research institutes of ferrous metallurgy should make a serious effort to develop and introduce new, more efficient methods of production quality control. This applies also to design organizations.

The reorganization of production quality control at metallurgical works requires a revision of the statute of the Departments of Technical Control, approved by the Ministry of the Ferrous Industry of the USSR in 1952. This statute does not correspond to the present structure of the Departments of Technical Control and in some cases even restricts the initiative of plant personnel in the improvement of the control system.

INNOVATORS OF THE STALINO METALLURGICAL WORKS

G. I. Zhivotinskaia

Senior Engineer

The group of innovators of the Stalino Metallurgical Works comprises more than 1500 men. In 1957, 987 men contributed to innovation work, this figure including 682 manual workers and 305 technical personnel. They submitted 2368 proposals (in 1956 – 1928 proposals), out of which 1342 were put into practice. Annual savings constituted 3.8 million rubles.

As a result of the introduction of technical improvements and rational innovations, 26 men were made free for other duties, the work of 256 men was made easier, and more than 500,000 kw-hr of electric power, 1000 tons of coal, 5400 tons of coke, 7700 tons of steam, and many other materials were saved.

Competitions for the best work on innovation and rationalization are organized at the plants. The best results in 1957 were achieved by innovators of the blast furnace plant, plate rolling, mixed rolling, electric, and other plants.

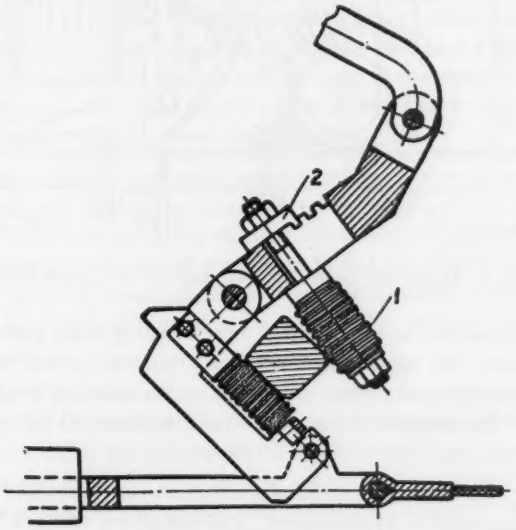


Fig. 1. Tilter key with the adjustable upper roller: 1) upper roller; 2) fixing washer.

A mechanic of the mixed rolling plant, G. M. Chekriakov, submitted 30 proposals in 1957; 25 of them were put into practice and resulted in an annual saving of 129,050 rubles. G. P. Kovtorin, foreman of the blast furnace plant, submitted 25 proposals, out of which 12 were approved and 8 were put into practice, resulting in 113,431 rubles annual savings. I. P. Popov, a fitter team leader of the plate rolling plant, submitted 14

proposals, out of which 12 were approved and 8 were put into practice, resulting in 67,835 rubles annual savings. V. I. Dubchenko, a team leader of the electricans of the blooming plant, submitted 21 proposals, out of which 14 were approved and 7 were put into practice, resulting in 46,503 rubles annual savings.

On the proposal of the blooming mill designer, B. G. Cherkasov, the design of the tilter key of the large-section 710 mill was modified. In 1952, electromechanical tilters were installed before and behind the roughing stand of this mill. It was, however, impossible to install such tilters at the finishing stand because the fixed distance between the axes of the rollers of the tilting key would not allow for the gripping and tilting of round and square pieces of 100 mm to 180 mm cross section.

B. G. Cherkasov proposed that the kinematic system of the tilting mechanism should be modified in such a way that the axis of the upper roller could be adjusted according to the cross section of the rolled piece. The axis of the upper roller passes through a slit in the upper lever and can be fixed in any of three positions by means of a rectangular washer with a longitudinal projection which fits into one of the grooves cut in the lever, the washer being fastened by a nut.

To reset the roller, it is necessary to unscrew the nut through only 10 mm (the height of the projection of the fixing washer), and this is done in about one minute.

The introduction of this innovation resulted in about 49,000 rubles annual savings and made 4 mill operators free for other duties.

Senior fitter-electrician V. I. Dubchenko proposed an original design for a miniature dc contactor.

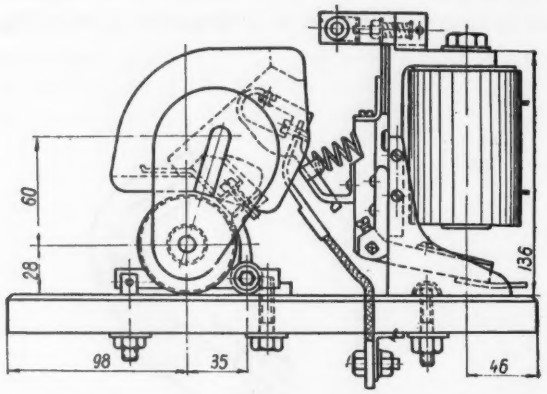


Fig. 2. Miniature contactor designed by V. I. Dubchenko.

The contactor (Fig. 2) is mounted on an insulating, heat-resisting board and consists of two assembled units situated one under the other. The upper unit constitutes a stationary contactor with a spark-quenching magnetic system and a spark-quenching chamber. It is made on the model of the KP-3 contactor. The lower part of the contactor consists of the contactor frame with a pull-in shunt coil and a driving system which supports the movable contact.

The design of V. I. Dubchenko was recognized as a technical improvement. Savings resulting from the introduction of this proposal amounted to 34,766 rubles. The design was sent to a manufacturing works.

In 1958, the innovators undertook extensive creative obligations.

MECHANIZATION OF LABOR-CONSUMING PROCESSES

V. I. Iagupov

Head of the Mechanization Section of the Stalino Metallurgical Work

Minor mechanization problems are taken care of at the Stalino Metallurgical Works by a special section which consists of a design bureau (three employees) and workshops manned by skilled filters, turners, welders, and smiths, supervised by a foreman. In addition, the section has an engineer who is responsible for the introduction of the new schemes. The mechanization section assists the plants in the improvement of equipment; it develops innovations, carries out experiments, prepares models, etc. Complex problems relating to the mechanization of labor-consuming processes are solved in conjunction with the mechanical, casting, and repair-and-construction shops of the Chief Mechanic's Department.

In the last 10 years, owing to the mechanization of labor-consuming processes, it has been possible to make 650 workers free for other duties and to facilitate the work of more than 1500 workers. In the blast furnace plant, conveyers have been built for the removal of coke fines. Previously, the hot slag on the slag yard of the open-hearth furnace plant was removed by hand; now, a special bucket hoist has been attached to the magnetic bridge crane. All open-hearth furnaces have been provided with oxygen supply mains.

Up to 1947, all auxiliary work on repairs of the open-hearth furnaces was done by hand. Now, vertical conveyers for the delivery of bricks to the furnace floor and roof, trough conveyers for the removal of debris, mixers and pumps for conveying the mixtures to the place of work, jib cranes and single cable hoists for the removal of rubbish from the regenerators and slag pockets, horizontal conveyers of various lengths for conveying bricks to the furnace under repair and to the separate parts of the furnace, conveyers for the removal of rubbish from the furnace, and other equipment have been installed.

The mechanization of operations in the scrap preparation plant is also made more extensive. Previously, all work here was done by hand, and the main machinery for scrap breaking was the drop hammers. Now, a break-up hall for breaking up large-size scrap, and sections for cutting and segregation, have been set up. Hence, the drop hammers could be dispensed with and 60 workers made free for other duties. The mechanization of handling the slag and rubbish dumps by means of an electromagnetic separator and other equipment made it possible to recover in 5 years about 300,000 tons of scrap and metallic additions for the blast furnaces from dumps.

In 1957, 63 new projects on the mechanization of labor-consuming for processes were carried out, and they resulted in making 56 workers free for other duties and facilitating the work of 340 operators. In the blast furnace plant an instrument with which the operator of the scale car can spray the ore in the skips was constructed. Thus, two men were made free for work in other sections. The erection of a mechanized table for the continuous delivery of the product in the section mill resulted in making 15 men available for other work.

Whereas previously rolled pieces on the finishing stand of the 710 mill were turned manually, now a special mechanical tilter is employed.

Several operations at the mixed-product rolling plant have been mechanized; a special die for making bedstead joints and a mechanized conveyance of initial material for bedsteads has been introduced. At the thin-sheet mill of this plant a scale breaker has been installed.

All the above measures have made it possible to increase the output considerably, to improve working conditions, and to make 20 men free for other duties.

However, there are still several sections at the works where labor-consuming processes must be mechanized. At the blooming and plate-rolling plants, the hot stamping of metal should be introduced in 1958. In the blast furnace plant the mechanization of the lubrication of the belt rollers of two casting machines is envisaged. We are working now on the mechanization of hot-top lining and we plan to mechanize the gripping of molds in the charge wing by means of a frame-holding device. The innovators and inventors at the works assist us greatly in our work.

INFORMATION ON ADVANCED PRACTICES

D. Oterin and L. Kostanda

The Stalino Metallurgical Works

Technical information and the dissemination of advanced practices of industrial innovators are of great importance for the growth of metal production. This work is carried out at the works by the Technical Information Bureau.

In 1957, 160 talks and lectures on various technical and economic topics were arranged for the workers and technical personnel of the Stalino Metallurgical Works. The lectures were given by scientific workers of institutes and members of the technical staff of our works.

In the course of the year there were 39 talks by outstanding workers, who related their experiences. Interesting talks were given by a senior mill operator, Kharagirlo, a gas operator of the blast furnace, Shcherbin, and others.

To study advanced practices of other works, missions to other works in the USSR and excursions to nearby works are frequently arranged. About 700 workers and technical staff took part in the 27 excursions made in 1957. As a result of these visits a large number of projects for improving production and the organization of work were submitted and more than 50 of these proposals were put into practice. Thus, following the practice of the "Zaporozhstal" Works, a horizontal stopper assembly was adopted at the open-hearth furnace plant. Following the practice of the Enakievka Works, a cooling plate over the pig-iron hole was adopted and so the life of the back wall of the open-hearth furnace was extended. Following the practice of the Kuznetsk Metallurgical Combine, the steam-blasting method for scale removal from plates during rolling and fast pneumatic manipulators were adopted.

The technical staff of the works carry out extensive work on the study and general adoption of the practices of leading workers. In the past year, the practices of 25 outstanding workers were studied; these included the foreman of the blast furnace, Samoilov, the team leader at the charge yard of the open-hearth plant, Zhernovoi, the senior mill operator, Derevianko, and others. Detailed reports on the practices of these innovators were compiled,and courses in which about 700 workers took part were arranged.

Great attention is paid to the dissemination of experience at the actual places of work. In 1957, owing to the appropriate arrangements, 1500 men extended their qualifications and learned an additional trade.

Since 1956, a bulletin on the exchange of technical experience has been published at the works. In the past year, 7 bulletins and 8 leaflets, containing descriptions of innovations which were of interest to several plants of the works, were published; in addition, 12 posters advertising the advanced methods of work of leading workers were displayed. To be more striking, these posters were not just printed but artistically executed on drawing paper.

Great importance is attached to extensive technical information. At 22 plants there are technical information boards, where, in 1957 alone, about 4,000 items of information, such as lists of literature, reviews, and notes on translated publications and articles from foreign journals, press information and stop-press news, etc., were displayed. Letters recommending the study of various technical literature, and information on advanced practices of the home and foreign metallurgists, are regularly sent to the technical staff of the works.

A great deal has been done to popularize periodical technical literature. In 1958, more than 900 members of the technical staff and workers in important trades are subscribing to various technical journals.

In the main, all the work on technical information is carried out in the Works' Palace of Technology, which comprises two lecture halls and blast furnace, open-hearth, steel rolling, innovation and Works' history rooms. The rooms contain diagrams, models, stands, colored posters and photographs representing production processes, and work done on rationalization. Especially popular is the Works' history room, where materials illustrating the history of the works from the time of its foundation in 1872 till the present day are exhibited.

A continuous improvement in the work on technical information and on the study and adoption of advanced practices greatly assists in the accomplishment of the common task of Works' personnel to increase the output of pig iron, steel, and rolled product.

OUTSTANDING METALLURGISTS

A. A. Baikov

An outstanding Russian metallurgist, one of the founders of the theory of metallurgical processes, Aleksandr Aleksandrovich Baikov, was born on July 25 (August 6, new calendar), 1870, into the family of a solicitor in a district town, Fatezh, in the Kursk Province. Soon after he was born, his parents moved to Kursk and in the early eighties of the 19th century Aleksander Baikov entered high school.

Even in high school A. A. Baikov showed great interest in chemistry. He started by carrying out simple chemical experiments, and in his last year at the school was even giving chemistry lectures to his classmates.

In 1889, A. A. Baikov completed his high school education and entered the physicomathematical faculty of the Petersburg University. In 1893, A. A. Baikov graduated with a 1st class degree from the University and was given a post in the department of D. P. Konovalov, the pupil and successor of the great Russian chemist, D. I. Mendeleev. In 1891 he joined the Institute of Communication Engineers, where he held the post of director of the chemical laboratory.

In 1899, A. A. Baikov was sent abroad on a scientific mission. He worked on chemical and metallographical problems in Paris in the laboratory of the well-known scientist A. Le Chatelier. On his return, A. A. Baikov gave a lecture on some alloys of copper and cadmium, and at the same time demonstrated a new type of pyrometer devised by Le Chatelier. In 1900, he made a report on copper-antimony alloys and on the phenomena of hardening observed in these alloys. This report later constituted the basis of his thesis.

In 1904, Baikov became professor of metallurgy in the newly established Petersburg Polytechnical Institute. To his students he gave, for the first time, his original lectures on general metallurgy and the metallurgy of copper and lead, on which lectures several generations of metallurgists were educated.

During his work at the Polytechnical Institute, A. A. Baikov educated a large group of scientists and industrial metallurgists, including B. V. Stark, V. N. Svechnikov, N. T. Gudtsov, and others. Under his guidance, the students of Aleksandr Aleksandrovich presented above 50 theses, many of which were published in scientific journals.

In 1910, A. A. Baikov took active part in the establishment of the Russian Metallurgical Society, which began the publication of a journal edited by Academician M. A. Pavlov. A. A. Baikov became scientific secretary to the Society; after the Revolution he became Deputy Chairman. He remained in this post until the formation of the All-Union Scientific and Technical Society of Metallurgists.

In 1918, A. A. Baikov went to Crimea to study the trasses of Karadag. Because of the Civil War, he was prevented from returning to Petersburg, and so he remained in Symferopol where he lectured on some fields of chemistry at the University. In 1921, A. A. Baikov returned to Petersburg and continued his work at the Polytechnical Institute. In 1925, he was elected Rector of the Institute. At the same time he was lecturing at the Military Engineering and Artillery Academies, at the Electrowelding Institute, and others.

The lectures given by Baikov were radically different from the courses and textbooks of his predecessors. His strictly scientific, logical approach, based on a deep understanding of physicochemical fundamentals of the processes, attracted a wide audience. In his work "Pyrite Smelting," published in 1925, A. A. Baikov discussed physicochemical fundamentals of the process of copper smelting from pyrites. In this work, earlier representations of copper smelting, based on an erroneous, too empirical approach, were completely rejected.

A. A. Baikov put a great deal of effort into establishing scientific fundamentals of the theory of metallurgical processes. At the same time, he never lost touch with the every-day needs of the metallurgical practice and worked on problems with which metallurgists were preoccupied at the time. Thus, in 1939, Baikov, in conjunction with M. M. Karnaukhov, carried out experiments on steelmaking in tilting open-hearth furnaces, using Kerch pig iron, which contained arsenic and phosphorus. The rails made of this steel stood the test excellently, and the slag when used as fertilizer was in no respect inferior to the basic slag.

When the State Institute for the Design of Metallurgical Works (Gipromez) was formed, Baikov became a consultant there and then became Chairman of the Technical Council. In 1927, A. A. Baikov was elected Corresponding Member of the Academy of Sciences, USSR, and was invited to work in the Institute of Metals. Very soon Baikov became Director of the Institute.

Since December, 1941, A. A. Baikov worked in Sverdlovsk in the Academy of Sciences. Here he was elected Vice-President of the Academy. He was then discovering new sources of raw materials, fuels and refractory materials for the ferrous industry in the eastern provinces of the USSR.

Since 1943, and until his last days, A. A. Baikov was the chairman of the Scientific and Technical Advice Council of the State Planning of the USSR. In May, 1945, Baikov was awarded the title of Hero of Socialist Labor.

A. A. Baikov died on April 6, 1946. His creative work did not stop until the day he died.

The Soviet Government perpetuated the name of this outstanding scientist. The Institute of Metallurgy of the Academy of Sciences of the USSR and the Laboratory of the Theory of Metallurgical Processes were named after him. Soviet metallurgists recall with love and respect the name of the founder of the theory of metallurgy – Academician Aleksandr Aleksandrovich Baikov.

METALLURGY ABROAD

ADVANCES IN OPEN-HEARTH STEELMAKING

Cand. Tech. Sci. D. A. Smoliarenko

Chairman of the All-Union Steelmaking Section of the NTO ChM*

In February, 1958, the Proceedings of the 39th Conference on Open-Hearth Steelmaking, which took place from April 9 to 11, 1956, in Cincinnati, Ohio, USA, were made available in the USSR.

Conferences on open-hearth steelmaking in the U.S.A. have been arranged annually, since 1925, by the National Open-Hearth Steelmaking Committee; metallurgists, physical chemists and practical metallurgists of various institutes and works are invited. Eleven hundred and five specialists from various parts of the USA, including well-known metallurgists and metalphysicists, such as John Chipman, T. L. Joseph, B. M. Larsen, Gilbert Soler, R. K. Kulp, R. S. Archer, T. D. Hess, J. L. Walton and others, took part in the 39th Conference.

According to the information in the journals, the 40th Conference on Open-Hearth Steelmaking took place in Pittsburgh in 1957.

In the Proceedings of the 39th Conference, we find various kinds of work on the steel production in the USA. Particularly detailed attention is devoted to the description of the application of statistical methods in the qualitative and quantitative evaluation of the steelmaking processes.

Steel output in the USA constitutes 90% by weight of all the output of ferrous and nonferrous metals. 90% of this steel is made in open-hearth furnaces.

In the past ten years, the capacity of the open-hearth furnaces in the USA has increased. According to the information of the American Iron and Steel Institute, relating to 613 furnaces in 1947 and 671 furnaces in 1956, the number of furnaces of more than 200 tons capacity increased from 30 to 204. The increase in the output of the open-hearth furnaces was achieved by doubling the weight of the charge, increasing the thermal load, intensifying fuel combustion and decarbonizing the bath with oxygen, atomizing the fuel oil with natural gas, increasing the temperature of the air of combustion, applying a preliminary desulfurization of pig iron, using immersion thermocouples for the temperature control of the bath, etc.

The increase of output per hour was attained by increasing the area of the hearth at the expense of reducing the cross section of the vertical ducts.

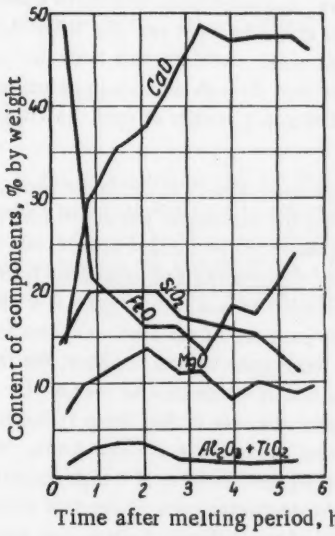
The introduction of auxiliary equipment for the mechanization of repair operations, suspension roofs for the regenerators, and the equipment for blowing out dust from under the checkers and from flues, made possible longer campaigns of the furnaces and shorter repair periods. The main ways of bringing about a further increase in productivity of the open-hearth plants in the USA are: improvement of charging conditions by increasing the load capacities of charging cranes and machines; increasing the size of molds and improving the preparation of scrap; expanding the steel-pouring equipment; improving fuel combustion by applying high-pressure gas and enriching the air with oxygen; extending the life of furnaces; improving the design of the furnaces and the quality of repairs; increasing the area of the hearth; increasing the weight of the heat and discharging the heat into two ladles; desiliconizing the pig iron, and supplying oxygen to the bath (through the roof).

The technology of steelmaking in the USA is similar to that specified in the standard technological instructions developed in the USSR on the production of killed and rimmed steel in basic open-hearth furnaces, operated on the basis of the scrap-and-ore process. The composition of the charge in the scrap-and-ore process varies within wide limits, depending mainly on the availability and the cost of scrap. In the USA, the

*Scientific and Technical Society of Ferrous Metallurgy.

amount of liquid pig iron in the charge constitutes 40-70% (average 45-55%). As a rule, initially the small-size scrap is charged to cover the furnace bottom, then limestone, ore, scrap, and finally liquid pig iron are charged. With this method of charging, the bottom is better preserved, the ore reacts faster with the additions of pig iron, and limestone is preserved for the formation of slag after the melting period.

The carbon and manganese regime of the heat, as well as the slag regime (Figure), are similar to the operational regime of the Soviet open-hearth plants. Since, however, very narrow limits of carbon content are required by standard specifications for steel in the USA, the heat is tapped when its carbon content is lower than specified and carbon is subsequently added into the ladle, in the form of ground coke or graphite. The yield of useful material in ingots per weight of metal portion of the charge is considerably lower than at the Magnitogorsk and the Kuznetsk Metallurgical Combines.



Variation of slag composition in the course of the heat.

Experiments carried out in the USA on making nonaging steel for deep drawing with the addition of vanadium showed that vanadium binds not only nitrogen but also carbon, which affects the aging of steel. At the same time, the surface of the steel plate is improved. In the USA, rimmed steel is also produced for deep drawing with the addition of titanium, which forms a stable compound – titanium carbide. This steel is meant to be covered with enamel. With the object of making ecomonies in ferroalloys, experiments are carried out in the USA on the application of exothermic alloys of chromium and manganese containing, in addition to carbon and silicon, sodium nitrate. These alloys are introduced into the ladle before the tapping of the heat. On melting, sodium nitrate reacts with the silicon in the alloy. A large quantity of heat is then liberated. When exothermic alloys are used, 95% of chromium and 90% of manganese is assimilated. To economize in scarce alloying elements (nickel, chromium, molybdenum), boron is used for alloy steel in the USA, the steel in the ladle being deoxidized with aluminum or titanium before the ferroallov with boron is added, because boron has great affinity for oxygen and nitrogen.

At the 39th Conference, several reports were presented on the operation of steelmaking plants in Europe; in one of the chapters of the Proceedings, information is given on the application of basic and acid refractories for the lining of open-hearth furnaces in different European countries (see Table). For comparison, it should be noted that out of 496 open-hearth furnaces in the USSR, 447 have been already converted to basic roofs.

The lack of natural sources of magnesite in the USA, England and several other European countries, and the high cost of chromite-magnesite brick, are limiting factors in the application of basic refractories for open-hearth furnaces in these countries (apart from Austria and Yugoslavia, where there are natural deposits of magnesites). In the USA, a thin layer of magnesite bricks (228 mm) is used for bottom lining, and, with the object of time saving in bottom fettling, the thick sintered layer is partly or completely replaced with a rammed layer of a specially prepared material (the composition of the mixture is not given).

The life of silica roofs varies, depending on the capacity of the furnace, and usually constitutes 150 to 400 heats. For open-hearth furnace roofs at several works, high-quality super-duty silica refractories with 0.2-0.4% aluminum oxide content are used, and thus the life of the roof is extended. A fairly frequent practice is to build "zebra" roofs consisting of alternating silica and chromite-magnesite bricks. The durability of such roofs was found to be better than that of silica roofs. The roof in basic open-hearth furnaces is of thrust-and-suspension construction with spring supports of the knuckle at the back wall. The life of the basic roofs varies between 400 to 600 heats, and in some cases constitutes 1500-2000 heats for furnaces of 60-100 ton capacity.

The use of rammed doors and runners should be especially noted. The life of rammed runners constitutes 260-500 heats; only a slight fettling of the runner is necessary after each heat.

As was reported at the Conference, oxygen is employed for the preliminary removal of silicon from pig iron. Liquid pig iron is blown through in the ladle, oxygen consumption constituting approximately 7-9 cu m/ton. When the semiproduct is used, the output of the open-hearth furnace markedly increases.

In the new open-hearth furnaces, the roofs of the regenerators, the inclined walls of vertical channels and ports, are made flat and suspended. In this way, a long life of the brickwork, including the junctions of the walls of vertical channels with the roofs of the slag pockets, is attained. The above remarks refer to the furnaces where gas is not heated in the regenerators, so that if the suspension roofs are not tight this does not result in gas leakage and contamination of the atmosphere in the plant.

The checkers are made of various bricks of ordinary shape, fire-clay bricks (35-40% of alumina) being preferred. At several works, the blowing-through of checkers (with steam or compressed air) or washing with water (sometimes with solution containing 1% oxalic acid) under pressure, and sometimes combined washing and blowing-through, are extensively employed. The life of checkers at small furnaces reaches 2,000-4,000 heats, the upper layers being replaced approximately every 500 heats. At some works the dust from the bottom of the regenerating chambers and the flues is blown out with steam introduced through nozzles in steam mains laid in the lining of the bottom. Then, the dust is vacuum-removed. In this way repairs of open-hearth furnaces are speeded up and the number of workers on repairs is reduced.

Characteristics of Open-Hearth Furnaces of Some European Countries

Country	Number of open-hearth furnaces		
	total	lined with refractories	
		silica (acid)	basic
Germany (West)	199	107	92
France	124	107	17
Italy	64	54	10
Yugoslavia	24	—	24
Austria	24	2	22
Sweden	44	28	16
Belgium	18	16	2
Denmark	8	4	4
Finland	2	—	2
Greece	2	1	1
Holland	10	2	8
Saar	12	6	6
Turkey	6	2	4
Total	537	329	208

The modern open-hearth furnaces are provided with equipment for the automatic control of fuel input, fuel-air ratio, pressure in the furnace proper, and the change of valves. Controlling and measuring instruments record the input of fuel, air, oxygen, and steam as well as the temperature of the roof, checkers and flue gases. On some open-hearth furnaces, the input of fuel is automatically controlled by means of a computer which reduces the rate of fuel input if the temperature of the roof exceeds the allowed limit. When mixed fuel (fuel oil and cold gas of a high calorific value) is used, the computer sums up the fuel consumption and the ratio of the different fuels is also automatically adjusted.

One of the chapters of the Proceedings relates the modeling of open-hearth furnaces with the object of studying heat transfer processes in furnaces, thus obtaining a general picture of some characteristics of the open-hearth furnace as a thermal unit. It should be pointed out in this connection that in the USSR Prof. Dr. Tech. Sci. M. A. Glinkov, Prof. Dr. Tech. Sci. P. M. Maslovskii, Cand. Tech. Sci. G. P. Ivantsov, and others are successfully studying heat transfer processes in open-hearth furnaces by means of modeling and the theory of similarity.

In recent years, the vacuum treatment of liquid steel, at a vacuum below 0.01 mm Hg, has been extensively employed in the steelmaking industry of the USA. The most widely employed method is degasification by the transfer of liquid metal from one ladle to another placed in a vacuum chamber.

A large part of the work of the Conference was devoted to the elucidation of problems related to the application of mathematical statistics to steelmaking processes. Statistical methods allow the establishment of the relationship – which in many cases cannot be established by other methods – between the industrial

factors under study. The use of statistical methods extends the scope of scientific research and facilitates a continuous check on production processes and the quality of products. These factors make statistics a powerful means in scientific research as well as in production control in the steelmaking industry. Several methods of applied statistics are treated as secret in the USA.

In the chapter which deals with the physical characteristics and chemical analysis of iron ore employed in open-hearth steelmaking, it is said that the planned steel productive capacity of the USA for 1970 is 185 million tons.* Analysis of the economic position of the USA throws doubt on such a statement. It has been reported in the press that, at present, the steelmaking industry of the USA works at only 50% of its productive capacity.

It was pointed out above that the conferences on the open-hearth industry are held anually in the USA. We give below some data on the number of participants at these conferences.

Year	1925	1929	1934	1938	1940	1944	1948	1950	1954	1956
Place of conference	Pitts-burgh	Chicago	Pitts-burgh	Buffalo	Pitts-burgh	Pitts-burgh	Pitts-burgh	Cincinnati	Chicago	Cincinnati
Number of participants	26	131	202	357	606	874	1067	900	1135	1105

In the Soviet Union, the All-Union meetings of steel producers are arranged periodically by the Scientific and Technical Society of Ferrous Metallurgy in various parts of our country. The meetings held indicate that they constitute an important means for the study of advanced experience accumulated at the various works of the country and for familiarizing a large body of specialists and scientific workers with recent advances in the science and technology of steelmaking.

*American "short" ton, equal to 907.2 kg.

SIGNIFICANCE OF ABBREVIATIONS MOST FREQUENTLY ENCOUNTERED IN SOVIET PERIODICALS

FIAN	Phys. Inst. Acad. Sci. USSR.
GDI	Water Power Inst.
GITI	State Sci.-Tech. Press
GITTL	State Tech. and Theor. Lit. Press
GONTI	State United Sci.-Tech. Press
Gosenergoizdat	State Power Press
Goskhimizdat	State Chem. Press
GOST	All-Union State Standard
GTTI	State Tech. and Theor. Lit. Press
IL	Foreign Lit. Press
ISN (Izd. Sov. Nauk)	Soviet Science Press
Izd. AN SSSR	Acad. Sci. USSR Press
Izd. MGU	Moscow State Univ. Press
LEIIZhT	Leningrad Power Inst. of Railroad Engineering
LET	Leningrad Elec. Engr. School
LETI	Leningrad Electrotechnical Inst.
LETIIZhT	Leningrad Electrical Engineering Research Inst. of Railroad Engr.
Mashgiz	State Sci.-Tech. Press for Machine Construction Lit.
MEP	Ministry of Electrical Industry
MES	Ministry of Electrical Power Plants
MESEP	Ministry of Electrical Power Plants and the Electrical Industry
MGU	Moscow State Univ.
MKhTI	Moscow Inst. Chem. Tech.
MOPI	Moscow Regional Pedagogical Inst.
MSP	Ministry of Industrial Construction
NII ZVUKSZAPIOI	Scientific Research Inst. of Sound Recording
NIKFI	Sci. Inst. of Modern Motion Picture Photography
ONTI	United Sci.-Tech. Press
OTI	Division of Technical Information
OTN	Div. Tech. Sci.
Stroiizdat	Construction Press
TOE	Association of Power Engineers
TsKTI	Central Research Inst. for Boilers and Turbines
TsNIEL	Central Scientific Research Elec. Engr. Lab.
TsNIEL-MES	Central Scientific Research Elec. Engr. Lab.—Ministry of Electric Power Plants
TsVTI	Central Office of Economic Information
UF	Ural Branch
VIESKh	All-Union Inst. of Rural Elec. Power Stations
VNIIM	All-Union Scientific Research Inst. of Meteorology
VNIIZhDT	All-Union Scientific Research Inst. of Railroad Engineering
VTI	All-Union Thermotech. Inst.
VZEI	All-Union Power Correspondence Inst.

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by D. D. SARATOVKIN

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Translated from Russian

THIS SIGNIFICANT volume has been extensively revised by the author from the 1953 edition; in particular with *fresh material derived from observations under the stereoscopic microscope.*

The first section deals briefly with some general concepts on crystallization, drawing an important distinction between *genetic* and *structural* types of crystals, including some aspects of the *defect crystal state.* The second section covers at length the illuminating ideas and observations of the 19th-century Russian metallurgist D. K. Chernov, who proposed many of the basic ideas of dendritic crystallization. The third section is an extended survey of current views on dendritic crystallization, in which the ideas of many Soviet and other scientists are briefly summarized and criticized. Section four presents the growth forms of real crystals; all types are reviewed, but only dendritic or closely related forms are selected for subsequent investigation.

Following sections discuss the causes and forms of crystal growth, with *detailed applications* to certain substances that have been extensively studied *(particularly the ammonium halides),* and to eutectics in metal and organic systems; a completely revised presentation on steel castings which provides a lucid explanation of how the various structures found in real castings can be fitted into the author's theory of dendritic crystallization. Nearly all the concepts developed earlier in the book are utilized in this final section.

The main bulk of the volume contains many *original* and *unpublished* ideas and observations, and is an excellent example of the modern macroscopic approach to the crystalline state by an experienced worker concerned with the infinite variety of real crystals—all of which is enhanced by a *profusion of explanatory line diagrams and sets of stereoscopic photographs.*

CB translations are by bilingual scientists, and include all photographic, diagrammatic and tabular material integral with the text.

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